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THE COMPARATIVE PSYCHOLOGY OF MAN.[1]

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WHILE discussing with two members of the Anthropological Institute the work to be undertaken by its psychological section, I made certain suggestions which they requested me to put in writing. When reminded, some months after, of the promise I had made to do this, I failed to recall the particular suggestions referred to; but, in the endeavor to remember them, I was led to glance over the whole subject of comparative human psychology. Hence resulted the following paper:

That making a general survey is useful as a preliminary to deliberate study, either of a whole or of any part, scarcely needs showing. Vagueness of thought accompanies the wandering about in a region without known bounds or landmarks. Attention devoted to some portion of a subject, in ignorance of its connection with the rest, leads to untrue conceptions. The whole cannot be rightly conceived without some knowledge of the parts; and no part can be rightly conceived out of relation to the whole.

To map out the comparative psychology of man must also conduce to the more methodic carrying on of inquiries. In this, as in other things, division of labor will facilitate progress; and, that there may be division of labor, the work itself must be systematically divided.

We may conveniently separate the entire subject into three main divisions, arranged in the order of increasing specialty.

The first division will treat of the degrees of mental evolution of different human types, generally considered: taking account of both the mass of mental manifestation and the complexity of mental manifestation. This division will include the relations of these characters to physical characters—the bodily mass and structure, and the cere

[1] Read before the London Anthropological Institute.

bral mass and structure. It will also include inquiries concerning the time taken in completing mental evolution, and the time during which adult mental power lasts; as well as certain most general traits of mental action, such as the greater or less persistence of emotions and of intellectual processes. The connection between the general mental type and the general social type should also be here dealt with.

In the second division may be conveniently placed apart, inquiries concerning the relative mental natures of the sexes in each race. Under it will come such questions as these: What differences of mental mass and mental complexity, if any, existing between males and females, are common to all races? Do such differences vary in degree, or in kind, or in both? Are there reasons for thinking that they are liable to change by increase or decrease? What relations do they bear in each case to the habits of life, the domestic arrangements, and the social arrangements? This division should also include in its scope the sentiments of the sexes toward one another, considered as varying quantitatively and qualitatively; as well as their respective sentiments toward offspring, similarly varying.

For the third division of inquiries may be reserved the more special mental traits distinguishing different types of men. One class of such specialties results from differences of proportion among faculties possessed in common; and another class results from the presence in some races of faculties that are almost or quite absent from others. Each difference in each of these groups, when established by comparison, has to be studied in connection with the stage of mental evolution reached, and has to be studied in connection with the habits of life and the social development, regarding it as related to these both as cause and consequence.

Such being the outlines of these several divisions, let us now consider in detail the subdivisions contained within each.

I.—Under the head of general mental evolution we may begin with the trait of—

1. *Mental Mass.*—Daily experiences show us that human beings differ in volume of mental manifestation. Some there are whose intelligence, high though it may be, produces little impression on those around; while there are some who, when uttering even commonplaces, do it so as to affect listeners in a disproportionate degree. Comparison of two such makes it manifest that, generally, the difference is due to the natural language of the emotions. Behind the intellectual quickness of the one there is not felt any power of character; while the other betrays a momentum capable of bearing down opposition—a potentiality of emotion that has something formidable about it. Obviously the varieties of mankind differ much in respect of this trait. Apart from kind of feeling, they are unlike in amount of feeling. The dominant races overrun the inferior races mainly in virtue of the

greater quantity of energy in which this greater mental mass shows itself. Hence a series of inquiries, of which these are some: (*a.*) What is the relation between mental mass and bodily mass? Manifestly, the small races are deficient in it. But it also appears that races much upon a par in size—as, for instance, an Englishman and a Damara—differ considerably in mental mass. (*b.*) What is its relation to mass of brain? and, bearing in mind the general law that, in the same species, size of brain increases with size of body (though not in the same proportion), how far can we connect the extra mental mass of the higher races with an extra mass of brain beyond that which is proper to their greater bodily mass? (*c.*) What relation, if any, is there between mental mass and the physiological state expressed in vigor of circulation and richness of blood, as severally determined by mode of life and general nutrition? (*d.*) What are the relations of this trait to the social state, as predatory or industrial, nomadic or agricultural?

2. *Mental Complexity.*—How races differ in respect of the more or less involved structures of their minds will best be understood, on recalling that unlikeness between the juvenile mind and the adult mind among ourselves which so well typifies the unlikeness between the minds of savage and civilized. In the child we see absorption in special facts. Generalities even of a low order are scarcely recognized; and there is no recognition of high generalities. We see interest in individuals, in personal adventures, in domestic affairs; but no interest in political or social matters. We see vanity about clothes and small achievements; but little sense of justice: witness the forcible appropriation of one another's toys. While there have come into play many of the simpler mental powers, there has not yet been reached that complication of mind which results from the addition of powers evolved out of these simpler ones. Kindred differences of complexity exist between the minds of lower and higher races; and comparisons should be made to ascertain their kinds and amounts. Here, too, there may be a subdivision of the inquiries: (*a.*) What is the relation between mental complexity and mental mass? Do not the two habitually vary together? (*b.*) What is the relation to the social state, as more or less complex?—that is to say, Do not mental complexity and social complexity act and react on each other?

3. *Rate of Mental Development.*—In conformity with the biological law, that the higher the organisms the longer they take to evolve, members of the inferior human races may be expected to complete their mental evolution sooner than members of the superior races; and we have evidence that they do this. Travelers from all regions comment, now on the great precocity of children among savage and semi-civilized peoples, and now on the early arrest of their mental progress. Though we scarcely need more proofs that this general contrast exists, there remains to be asked the question, whether it is

consistently maintained throughout all orders of races, from the lowest to the highest—whether, say, the Australian differs in this respect from the Hindoo, as much as the Hindoo does from the European. Of secondary inquiries coming under this sub-head may be named several: (*a.*) Is this more rapid evolution and earlier arrest always unequally shown by the two sexes; or, in other words, are there in lower types proportional differences in rate and degree of development, such as higher types show us? (*b.*) Is there in many cases, as there appears to be in some cases, a traceable relation between the period of arrest and the period of puberty? (*c.*) Is mental decay earlier in proportion as mental evolution is rapid? (*d.*) Can we in other respects assert that, where the type is low, the entire cycle of mental changes between birth and death—ascending, uniform, descending—comes within a shorter interval?

4. *Relative Plasticity.*—Is there any relation between the degree of mental modifiability which remains in adult life, and the character of the mental evolution in respect of mass, complexity, and rapidity? The animal kingdom at large yields us reasons for associating an inferior and more rapidly-completed mental type with a relatively automatic nature. Lowly-organized creatures, guided almost entirely by reflex actions, are in but small degrees changeable by individual experiences. As the nervous structure complicates, its actions become less rigorously confined within preëstablished limits; and, as we approach the highest creatures, individual experiences take larger and larger shares in moulding the conduct: there is an increasing ability to take in new impressions and to profit by the acquisitions. Inferior and superior human races are contrasted in this respect. Many travelers comment on the unchangeable habits of savages. The semi-civilized nations of the East, past and present, were, or are, characterized by a greater rigidity of custom than characterizes the more civilized nations of the West. The histories of the most civilized nations show us that in their earlier times the modifiability of ideas and habits was less than it is at present. And, if we contrast classes or individuals around us, we see that the most developed in mind are the most plastic. To inquiries respecting this trait of comparative plasticity, in its relations to precocity and early completion of mental development, may be fitly added inquiries respecting its relations to the social state, which it helps to determine, and which reacts upon it.

5. *Variability.*—To say of a mental nature that its actions are extremely inconstant, and at the same time to say that it is a relatively unchangeable nature, apparently implies a contradiction. When, however, the inconstancy is understood as referring to the manifestations which follow one another from minute to minute, and the unchangeableness to the average manifestations, extending over long periods, the apparent contradiction disappears; and it becomes com-

prehensible that the two traits may, and ordinarily do, coexist. An infant, quickly weary with each kind of perception, wanting ever a new object, which it soon abandons for something else, and alternating a score times a day between smiles and tears, shows us a very small persistence in each kind of mental action: all its states, intellectual and emotional, are transient. Yet, at the same time, its mind cannot be easily changed in character. True, it changes spontaneously in due course; but it long remains incapable of receiving ideas or emotions beyond those of simple orders. The child exhibits less rapid variations, intellectual and emotional, while its educability is greater. Inferior human races show us this combination, great rigidity of general character, with great irregularity in its passing manifestations. Speaking broadly, while they resist permanent modification they lack intellectual persistence, and they lack emotional persistence. Of various low types we read that they cannot keep the attention fixed beyond a few minutes on any thing requiring thought even of a simple kind. Similarly with their feelings: these are less enduring than those of civilized men. There are, however, qualifications to be made in this statement; and comparisons are needed to ascertain how far these qualifications go. The savage shows great persistence in the action of the lower intellectual faculties. He is untiring in minute observation. He is untiring, also, in that kind of perceptive activity which accompanies the making of his weapons and ornaments: often persevering for immense periods in carving stones, etc. Emotionally, too, he shows persistence not only in the motives prompting these small industries, but also in certain of his passions—especially in that of revenge. Hence, in studying the degrees of mental variability shown us in the daily lives of the different races, we must ask how far variability characterizes the whole mind, and how far it holds only of parts of the mind.

6. *Impulsiveness.*—This trait is closely allied with the last: unenduring emotions are emotions which sway the conduct now this way and now that, without any consistency. The trait of impulsiveness may, however, be fitly dealt with separately, because it has other implications than mere lack of persistence. Comparisons of the lower human races with the higher appear generally to show that, along with brevity of the passions, there goes violence. The sudden gusts of feeling which men of inferior types display are excessive in degree as they are short in duration; and there is probably a connection between these two traits: intensity sooner producing exhaustion. Observing that the passions of childhood illustrate this connection, let us turn to certain interesting questions concerning the decrease of impulsiveness which accompanies advance in evolution. The nervous processes of an impulsive being are less remote from reflex actions than are those of an unimpulsive being. In reflex actions we see a simple stimulus passing suddenly into movement: little or no control

being exercised by other parts of the nervous system. As we ascend to higher actions, guided by more and more complicated combinations of stimuli, there is not the same instantaneous discharge in simple motions; but there is a comparatively deliberate and more variable adjustment of compound motions, duly restrained and proportioned. It is thus with the passions and sentiments in the less developed natures and in the more developed natures. Where there is but little emotional complexity, an emotion, when excited by some occurrence, explodes in action before the other emotions have been called into play; and each of these, from time to time, does the like. But the more complex emotional structure is one in which these simpler emotions are so coördinated that they do not act independently. Before excitement of any one has had time to cause action, some excitement has been communicated to others—often antagonistic ones—and the conduct becomes modified in adjustment to the combined dictates. Hence results a decreased impulsiveness, and also a greater persistence. The conduct pursued, being prompted by several emotions coöperating in degrees which do not exhaust them, acquires a greater continuity; and while spasmodic force becomes less conspicuous, there is an increase in the total energy.

Examining the facts from this point of view, there are sundry questions of interest to be put respecting the different races of men: (*a.*) To what other traits than degree of mental evolution is impulsiveness related? Apart from difference in elevation of type, the New-World races seem to be less impulsive than the Old-World races. Is this due to constitutional apathy? Can there be traced (other things equal) a relation between physical vivacity and mental impulsiveness? (*b.*) What connection is there between this trait and the social state? Clearly a very explosive nature—such as that of the Bushman—is unfit for social union; and, commonly, social union, when by any means established, checks impulsiveness. (*c.*) What respective shares in checking impulsiveness are taken by the feelings which the social state fosters—such as the fear of surrounding individuals, the instinct of sociality, the desire to accumulate property, the sympathetic feelings, the sentiment of justice? These, which require a social environment for their development, all of them involve imaginations of consequences more or less distant; and thus imply checks upon the promptings of the simpler passions. Hence arise the questions—In what order, in what degrees, and in what combinations do they come into play?

7. One further general inquiry of a different kind may be added: What effect is produced on mental nature by mixture of races? There is reason for believing that, throughout the animal kingdom, the union of varieties that have become widely divergent is physically injurious; while the union of slightly-divergent varieties is physically beneficial. Does the like hold with the mental nature? Some facts seem

to show that mixture of human races extremely unlike produces a worthless type of mind—a mind fitted neither for the kind of life led by the higher of the two races, nor for that led by the lower—a mind out of adjustment to all conditions of life. Contrariwise, we find that peoples of the same stock, slightly differentiated by lives carried on in unlike circumstances for many generations, produce by mixture a mental type having certain superiorities. In his work on "The Huguenots," Mr. Smiles points out how large a number of distinguished men among us have descended from Flemish and French refugees; and M. Alphonse de Candolle, in his "Histoire des Sciences et des Savants depuis deux Siècles," shows that the descendants of French refugees in Switzerland have produced an unusually great proportion of scientific men. Though, in part, this result may be ascribed to the original natures of such refugees, who must have had that independence which is a chief factor in originality, yet it is probably in part due to mixture of races. For thinking this, we have evidence which is not open to two interpretations. Prof. Morley draws attention to the fact that, during seven hundred years of our early history, "the best genius of England sprang up on the line of country in which Celts and Anglo-Saxons came together." In like manner, Mr. Galton, in his "English Men of Science," shows that in recent days these have mostly come from an inland region, running generally from north to south, which we may reasonably presume contains more mixed blood than do the regions east and west of it. Such a result seems probable *a priori*. Two natures respectively adapted to slightly unlike sets of social conditions may be expected by their union to produce a nature somewhat more plastic than either—a nature more impressible by the new circumstances of advancing social life, and therefore more likely to originate new ideas and display modified sentiments. The comparative psychology of man may, then, fitly include the mental effects of mixture; and among derivative inquiries we may ask, How far the conquest of race by race has been instrumental in advancing civilization by aiding mixture, as well as in other ways?

II.—The second of the three leading divisions named at the outset is less extensive. Still, concerning the relative mental natures of the sexes in each race, questions of much interest and importance may be raised:

1. *Degree of Difference between the Sexes.*—It is an established fact that, physically considered, the contrast between males and females is not equally great in all types of mankind. The bearded races, for instance, show us a greater unlikeness between the two than do the beardless races. Among South American tribes, men and women have a greater general resemblance in form, etc., than is usual elsewhere. The question, then, suggests itself, Do the mental natures of the sexes differ in a constant or in a variable degree? The differ-

ence is unlikely to be a constant one; and, looking for variation, we may ask what is its amount, and under what conditions does it occur?

2. *Difference in Mass and in Complexity.*—The comparisons between the sexes, of course, admit of subdivisions parallel to those made in comparisons between the races. Relative mental mass and relative mental complexity have chiefly to be observed. Assuming that the great inequality in the cost of reproduction to the two sexes is the cause of unlikeness in mental mass, as in physical mass, this difference may be studied in connection with reproductive differences presented by the various races, in respect of the ages at which reproduction commences, and the period over which it lasts. An allied inquiry may be joined with this; namely, how far the mental developments of the two sexes are affected by their relative habits in respect to food and physical exertion? In many of the lower races, the women, treated with great brutality, are physically very inferior to the men; excess of labor and defect of nutrition being apparently the combined causes. Is any arrest of mental development simultaneously caused?

3. *Variation of the Differences.*—If the unlikeness, physical and mental, of the sexes is not constant, then, supposing all races have diverged from one original stock, it follows that there must have been transmission of accumulated differences to those of the same sex in posterity. If, for instance, the prehistoric type of man was beardless, then the production of a bearded variety implies that within that variety the males continued to transmit an increasing amount of beard to descendants of the same sex. This limitation of heredity by sex, shown us in multitudinous ways throughout the animal kingdom, probably applies to the cerebral structures as much as to other structures. Hence the question, Do not the mental natures of the sexes in alien types of man diverge in unlike ways and degrees?

4. *Causes of the Differences.*—Is any relation to be traced between this variable difference and the variable parts the sexes play in the business of life? Assuming the cumulative effects of habit on function and structure, as well as the limitation of heredity by sex, it is to be expected that, if in any society the activities of one sex, generation after generation, differ from those of the other, there will arise sexual adaptations of mind. Some instances in illustration may be named. Among the Africans of Loango and other districts, as also among some of the Indian Hill-tribes, the men and women are strongly contrasted as respectively inert and energetic: the industry of the women having apparently become so natural to them that no coercion is needed. Of course, such facts suggest an extensive series of questions. Limitation of heredity by sex may account both for those sexual differences of mind which distinguish men and women in all races and for those which distinguish them in each race, or each so-

ciety. An interesting subordinate inquiry may be, how far such mental differences are inverted in cases where there is inversion of social and domestic relations; as among those Khasi Hill-tribes whose women have so far the upper hand that they turn off their husbands in a summary way if they displease them.

5. *Mental Modifiability in the Two Sexes.*—Along with comparisons of races in respect to mental plasticity may go parallel comparisons of the sexes in each race. Is it true always, as it appears to be generally true, that women are less modifiable than men? The relative conservatism of women—their greater adhesion to established ideas and practices—is manifest in many civilized and semi-civilized societies. Is it so among the uncivilized? A curious instance of greater adhesion to custom by women than by men is given by Dalton, as occurring among the Juangs, one of the lowest wild tribes of Bengal. Until recently the only dress of both sexes was something less than that which the Hebrew legend gives to Adam and Eve. Years ago the men were led to adopt a cloth bandage round the loins, in place of the bunch of leaves; but the women adhere to the aboriginal habit: a conservatism shown where it might have been least expected.

6. *The Sexual Sentiment.*—Results of value may be looked for from comparisons of races made to determine the amounts and characters of the higher feelings to which the relation of the sexes gives rise. The lowest varieties of mankind have but small endowments of these feelings. Among varieties of higher types, such as the Malayo-Polynesians, these feelings seem considerably developed: the Dyaks, for instance, sometimes display them in great strength. Speaking generally, they appear to become stronger with the advance of civilization. Several subordinate inquiries may be named: (*a.*) How far is development of the sexual sentiment dependent upon intellectual advance—upon growth of imaginative power? (*b.*) How far is it related to emotional advance; and especially to evolution of those emotions which originate from sympathy? What are its relations to polyandry and polygyny? (*c.*) Does it not tend toward, and is it not fostered by, monogamy? (*d.*) What connection has it with maintenance of the family bond, and the consequent better rearing of children?

III.—Under the third head, to which we may now pass, come the more special traits of the different races:

1. *Imitativeness.*—One of the characteristics in which the lower types of men show us a smaller departure from reflex action than do the higher types is, their strong tendency to mimic the motions and sounds made by others—an almost involuntary habit which travelers find it difficult to check. This meaningless repetition, which seems to imply that the idea of an observed action cannot be framed in the mind of the observer without tending forthwith to discharge itself in the action conceived (and every ideal action is a nascent form of the

consciousness accompanying performance of such action), evidently diverges but little from the automatic; and decrease of it is to be expected along with increase of self-regulating power. This trait of automatic mimicry is evidently allied with that less automatic mimicry which shows itself in greater persistence of customs. For customs adopted by each generation from the last, without thought or inquiry, imply a tendency to imitate which overmasters critical and skeptical tendencies: so maintaining habits for which no reason can be given. The decrease of this irrational mimicry, strongest in the lowest savage and feeblest in the highest of the civilized, should be studied along with the successively higher stages of social life, as being at once an aid and a hindrance to civilization; an aid in so far as it gives that fixity to the social organization without which a society cannot survive; a hindrance in so far as it offers resistance to changes of social organization that have become desirable.

2. *Incuriosity.*—Projecting our own natures into the circumstances of the savage, we imagine ourselves as marveling greatly on first seeing the products and appliances of civilized life. But we err in supposing that the savage has feelings such as we should have in his place. Want of rational curiosity respecting these incomprehensible novelties is a trait remarked of the lowest races wherever found; and the partially-civilized races are distinguished from them as exhibiting rational curiosity. The relation of this trait to the intellectual nature, to the emotional nature, and to the social state, should be studied.

3. *Quality of Thought.*—Under this vague head may be placed many sets of inquiries, each of them extensive: (*a.*) The degree of generality of the ideas; (*b.*) The degree of abstractness of the ideas; (*c.*) The degree of definiteness of the ideas; (*d.*) The degree of coherence of the ideas; (*e.*) The extent to which there have been developed such notions as those of *class*, of *cause*, of *uniformity*, of *law*, of *truth*. Many conceptions, which have become so familiar to us that we assume them to be the common property of all minds, are no more possessed by the lowest savages than they are by our own children; and comparisons of types should be so made as to elucidate the processes by which such conceptions are reached. The development under each head has to be observed: (*a.*) Independently in its successive stages; (*b.*) In connection with the coöperative intellectual conceptions; (*c.*) In connection with the progress of language, of the arts, and of social organization. Already linguistic phenomena have been used in aid of such inquiries; and more systematic use of them should be made. Not only the number of general words, and the number of abstract words, in a people's vocabulary should be taken as evidence, but also their *degrees* of generality and abstractness; for there are generalities of the first, second, third, etc., orders and abstractions similarly ascending in degree. *Blue* is an abstraction referring to one class of

impressions derived from visible objects; *color* is a higher abstraction, referring to many such classes of visual impressions; *property* is a still higher abstraction, referring to classes of impressions received not through the eyes alone, but through other sense-organs. If generalities and abstractions were arranged in the order of their extensiveness and in their grades, tests would be obtained which, applied to the vocabularies of the uncivilized, would yield definite evidence of the intellectual stages reached.

4. *Peculiar Aptitudes.*—To such specialties of intelligence as mark different degrees of evolution have to be added the minor ones related to modes of life: the kinds and degrees of faculty which have become organized in adaptation to daily habits—skill in the use of weapons, powers of tracking, quick discrimination of individual objects. And under this head may fitly come inquiries concerning some race-peculiarities of the æsthetic class, not at present explicable. While the remains from the Dordogne caves show us that their inhabitants, low as we must suppose them to have been, could represent animals, both by drawing and carving, with some degree of fidelity, there are existing races, probably higher in other respects, who seem scarcely capable of recognizing pictorial representations. Similarly with the musical faculty. Almost or quite wanting in some inferior races, we find it in other races, not of high grade, developed to an unexpected degree. instance the negroes, some of whom are so innately musical that, as I have been told by a missionary among them, the children in native schools, when taught European psalm-tunes, spontaneously sing seconds to them. Whether any causes can be discovered for race-peculiarities of this kind is a question of interest.

5. *Specialties of Emotional Nature.*—These are worthy of careful study, as being intimately related to social phenomena—to the possibility of social progress, and to the nature of the social structure. Of those to be chiefly noted there are—(*a.*) Gregariousness or sociality—a trait in the strength of which races differ widely: some, as the Mantras, being almost indifferent to social intercourse; others being unable to dispense with it. Obviously the degree of the desire for the presence of fellow-men affects greatly the formation of social groups, and consequently underlies social progress. (*b.*) Intolerance of restraint. Men of some inferior types, as the Mapuché, are ungovernable; while those of other types, no higher in grade, not only submit to restraint, but admire the persons exercising it. These contrasted traits have to be observed in connection with social evolution; to the early stages of which they are respectively antagonistic and favorable. (*c.*) The desire for praise is a trait which, common to all races, high and low, varies considerably in degree. There are quite inferior races, as some of those in the Pacific States, whose members sacrifice without stint to gain the applause which lavish generosity brings; while, elsewhere, applause is sought with less eagerness. Notice should be

taken of the connection between this love of approbation and the social restraints, since it plays an important part in the maintenance of them. (*d.*) The acquisitive propensity. This, too, is a trait the various degrees of which, and the relations of which to the social state, have to be especially noted. The desire for property grows along with the possibility of gratifying it; and this, extremely small among the lowest men, increases as social developement goes on. With the advance from tribal property to family property and individual property, the notion of private right of possession gains definiteness, and the love of acquisition strengthens. Each step toward an orderly social state makes larger accumulations possible, and the pleasures achievable by them more sure; while the resulting encouragement to accumulate leads to increase of capital and further progress. This action and reaction of the sentiment and the social state, should be in every case observed.

6. *The Altruistic Sentiments.*—Coming last, these are also highest. The evolution of them in the course of civilization shows us very clearly the reciprocal influences of the social unit and the social organism. On the one hand, there can be no sympathy, nor any of the sentiments which sympathy generates, unless there are fellow-beings around. On the other hand, maintenance of union with fellow-beings depends in part on the presence of sympathy, and the resulting restraints on conduct. Gregariousness or sociality favors the growth of sympathy; increased sympathy conduces to closer sociality and a more stable social state; and so, continuously, each increment of the one makes possible a further increment of the other. Comparisons of the altruistic sentiments resulting from sympathy, as exhibited in different types of men and different social states, may be conveniently arranged under three heads: (*a.*) Pity, which should be observed as displayed toward offspring, toward the sick and aged, and toward enemies. (*b.*) Generosity (duly discriminated from the love of display) as shown in giving; as shown in the relinquishment of pleasures for the sake of others; as shown by active efforts on others' behalf. The manifestations of this sentiment, too, are to be noted in respect of their range—whether they are limited to relatives; whether they extend only to those of the same society; whether they extend to those of other societies; and they are also to be noted in connection with the degree of providence—whether they result from sudden impulses obeyed without counting the cost, or go along with a clear foresight of the future sacrifices entailed. (*c.*) Justice. This most abstract of the altruistic sentiments is to be considered under aspects like those just named, as well as under many other aspects—how far it is shown in regard to the lives of others; how far in regard to their property, and how far in regard to their various minor claims. And the comparisons of men in respect of this highest sentiment should, beyond all others, be carried on along with observations on the accompanying

social state, which it largely determines—the form and actions of government; the character of the laws; the relations of classes.

Such, stated as briefly as consists with clearness, are the leading divisions and subdivisions under which the Comparative Psychology of Man may be arranged. In going rapidly over so wide a field, I have doubtless overlooked much that should be included. Doubtless, too, various of the inquiries named will branch out into subordinate inquiries well worth pursuing. Even as it is, however, the programme is extensive enough to occupy numerous investigators who may with advantage take separate divisions.

Though, after occupying themselves with primitive arts and products, anthropologists have devoted their attention mainly to the physical characters of the human races, it must, I think, be admitted that the study of these yields in importance to the study of their psychical characters. The general conclusions to which the first set of inquiries may lead cannot so much affect our views respecting the highest classes of phenomena as can the general conclusions to which the second set may lead. A true theory of the human mind vitally concerns us; and systematic comparisons of human minds, differing in their kinds and grades, will help us in forming a true theory. Knowledge of the reciprocal relations between the characters of men and the characters of the societies they form must influence profoundly our ideas of political arrangements. When the interdependence of individual nature and social structure is understood, our conceptions of the changes now taking place, and hereafter to take place, will be rectified. A comprehension of mental development as a process of adaptation to social conditions, which are continually remoulding the mind, and are again remoulded by it, will conduce to a salutary consciousness of the remoter effects produced by institutions upon character, and will check the grave mischiefs which ignorant legislation now causes. Lastly, a right theory of mental evolution as exhibited by humanity at large, giving a key, as it does, to the evolution of the individual mind, must help to rationalize our perverse methods of education, and so to raise intellectual power and moral nature.

THE HORSESHOE NEBULA IN SAGITTARIUS.

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IN the number of THE POPULAR SCIENCE MONTHLY for July, 1874, I gave a brief account of the successive observations of the great nebula of Orion, from 1656 to 1874, and I pointed out how instructive such an historical review was in its bearing upon the improvement of

our means of observation and as an example of how the standard of such work has been gradually raised. It will be interesting to trace in the same way the history of the Horseshoe Nebula in Sagittarius, which, next to the great nebulosities of Orion and Andromeda, is the most curious of these objects, and which perhaps as much as any other deserves careful study.

Its discovery dates back about a hundred years to the time of Messier, the assiduous astronomer of the Observatoire de la Marine at Paris; it is No. 17 of his list, which comprises most of the brighter and more remarkable nebulæ of the northern sky. It was at this time that Sir William Herschel, the famous astronomer of England, with instruments far superior in power to those of Messier, was forming his great catalogues of the nebulæ discovered in his "sweeps." Messier wisely used his smaller instrument in the endeavor to obtain accurate positions for those found by him, and he has left us monographic studies of the Orion and the Andromeda nebulæ ("Mémoires de l'Académie des Sciences," 1771 and 1807), which are almost the first trustworthy works of the kind, and which are the beginnings from which sprang the elaborate drawings of Lassell, Rosse, Struve and Bond.

FIG. 1.—J. HERSCHEL, 1833.

From the time of Messier to 1826, when Sir John Herschel published his first figure of the Orion nebula, almost nothing was done in this line of research; but in 1833 a study of the Horseshoe Nebula was published by Sir John Herschel, together with many other similar drawings, in the "Philosophical Transactions" (*see* Fig. 1). This was the first considerable and systematic attempt to accurately figure the nebulæ, and it doubtless turned the attention of astronomers generally to this branch, the importance of which was manifest. If so many of the fixed stars changed in brilliancy and in position, why should not

the same thing occur among the nebulæ? And if such changes were once established, would not an important increase of our knowledge accrue, concerning these objects of which almost nothing was known? It was one of the avowed objects of Sir John Herschel's celebrated journey to the Cape of Good Hope to figure the nebulæ of the southern sky, and, while there, the drawing given in Fig. 2 was made, although it was not published until 1847.

FIG. 2.—J. HERSCHEL, 1837.

As we have said, Herschel's paper of 1833 created a wide-spread interest among astronomers, and about 1836 two monographic studies of the Horseshoe Nebula were begun, under circumstances so different as to deserve our attention. Lamont, the accomplished director of the Observatory of Munich, and Mason, an undergraduate of Yale College, commenced observations at about the same time: one being supplied with all the appliances which were known to astronomers,

and devoting all his energies to his chosen science in a city which was then the most famous in the world for its astronomical instruments; and the other, a mere boy, oppressed by narrow circumstances, working in the intervals of his college duties with a telescope which he had himself constructed, with a fellow-student (Mr. Hamilton L. Smith) as his only assistant.

The work of both astronomers (for it is impossible to deny to Mason that title) is of great excellence, but it will not be claiming too much to assert that Mason's was by far the most valuable monographic study of a nebula which had appeared, and indeed, in its thorough appreciation of the problems to be solved and in its most skillful adaptation of the existing means toward that end, it deserves to rank with the greatest works of this class, with Bond's, Lassell's, Rosse's and Struve's. It is not only in the observations themselves nor in the exquisite and accurate drawings which accompany the memoir that we feel this excellence, but in the philosophical grasp of the whole subject and the masterly appreciation of the fundamental ideas of the problem. His memoir contains so much that bears on this general aspect, that we quote from it largely, as it is too little known among those not professional astronomers:

"Although a period of nearly fifty years has now elapsed since the researches of the elder Herschel exposed to us the wide distribution of nebulous matter through the universe, we are still almost as ignorant as ever of its nature and intention. The same lapse of time that, among his extensive lists of double stars, has revealed to us the revolution of sun around sun, and given us a partial insight into the internal economy of those remote sidereal systems, has been apparently insufficient to discover any changes of a definite character in the nebulæ, and thereby to inform us at all of their past history, the form of their original creation, or their future destiny. At the same time, the detection of such changes is in the highest degree desirable, since no other sources of evidence can be safely relied upon in these inquiries. That the efforts of astronomers have thus far ended, at least, in vague and contradictory conjectures, is principally attributable to the great difficulty of originally observing, and of describing to future observers, bodies so shapeless and indeterminate in their forms, with the requisite precision. For we cannot doubt, authorized as we are to extend the laws of gravitation far into the recesses of space, that these masses of diffused matter are actually undergoing vast revolutions in form and constitution. The main object of this paper is to inquire how far that minute accuracy which has achieved such signal discoveries in the allied department of the double stars may be introduced into the observation of nebulæ, by modes of examination and description more peculiarly adapted to this end than such as can be employed in general reviews of the heavens. . . . It will conduce to a clearer understanding of our object to point out, generally and rapidly, the distinctions between our own theory of observation and that commonly adopted. It consists not in an extensive review, but in confining the attention to a few individuals; upon these exercising a long and minute scrutiny, during a succession of evenings; rendering even the slightest particulars of each nebula as precise as repeated observation and comparison with varied precautions can make them, and confirming each more doubtful and less legible of its features by a repetition of suspi-

cions, which are of weight in proportion as they accumulate; and, lastly, when practicable, correcting by comparison of the judgments of different persons at the same time.

"The assistance which is rendered to the faithful description of these remarkable objects by thus laying a groundwork of stars, may be well illustrated by the familiar expedient of artists, who divide any complicated engraving which they would copy, into a great number of squares, their intended sketch occupying a similar number. The stars, which are apparently interwoven throughout the whole extent of the nebula, furnish a set of thickly-distributed natural points of reference, which, truly transferred to the paper, are as available as the cross-lines of the artist in limiting and fixing the appearance of the future drawing.

"In nebulæ of great extent, however correctly estimated may be the stars immediately around the standard of reference, those in the distant parts of the nebula are liable to suffer from an accumulation of errors of nearly the same kind as that arising in an extended trigonometrical survey. But if the places of the larger stars are well settled by fixed instruments, there will be far less room for error in *estimations* which spread, as from so many centres, over the remaining intervals.

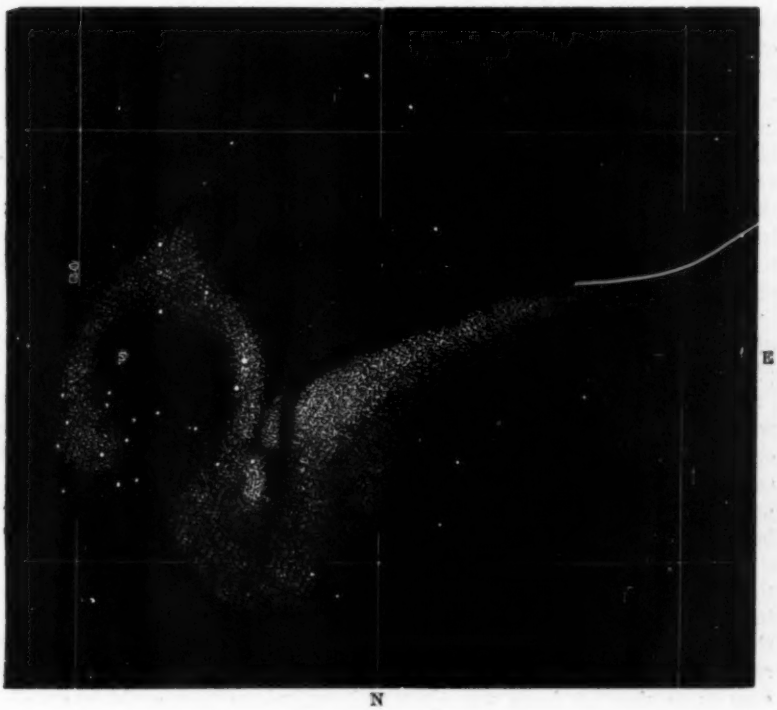


FIG. 3.—MASON, 1839.

"I will here speak of a method that I hit upon for the exact representation of nebulæ, which has essentially contributed to the accuracy of the accompanying delineations. It was first suggested by the method usually adopted for the representation of heights above the sea-level on geographical maps, by drawing

curves which represent horizontal sections of hill and valley at successive elevations above the level of the sea—that is, by lines of equal height—and it is the same in its principle. It is obvious that, if lines be imagined in the field of view, winding around through all those portions of a nebula which have exactly equal brightness, these lines, transferred to our chart of stars, will give a faithful representation of the nebula and of its minutiæ, and of the suddenness as well as of the amount of transition from one degree of shade to another.

"By far the greatest obstacles to the successful comparison of modern observations on nebulæ with those which own, at least, a brief antiquity, exist in the want of precision with which the labors of former observers have been conducted, and hence all attempts to trace the slow progress of their changes end in uncertain conjectures and conflicting probabilities. I shall not, therefore, incur the charge of unnecessary minuteness in endeavoring to render, by every means, our knowledge of the present form and state of at least these few nebulæ, as far as possible, standard; and, although laden with the necessary imperfections of original observations, yet free from adventitious and unnecessary vagueness in the communication of them. In order to supply, to any future observer, those slight particulars which a chart cannot easily urge upon the notice of any but the original compiler, and further, to indicate the degree of certainty with which different features of the nebulæ were recognized, it is thought proper to bring under this head the enumeration of various facts not expressed in the journal of observations. These are divided into '*things certain*,' '*nearly certain*,' '*strongly suspected*,' and '*slightly suspected*.' Thus much for observation—for rendering the idea of the object as perfect as may be in the mind of the observer. For the most unimpaired communication of this idea or perception, the theory of the process adopted is briefly—1. To form an accurate chart of all stars capable of micrometrical *measurement* in and around the nebula. 2. From these, as the greater landmarks, to fill in with all the lesser stars, down to the *minimum visibile* by *estimation*, which, with care, need not fall far short of ordinary measurement. 3. On this, as a foundation, to lay down the nebula.

"The first intention was to intrust entirely to careful *estimation* the copying of the stars which were to form the groundwork of the nebula, since no means of measurement were then at hand. The following is a sketch of the course of procedure adopted in pursuance of this plan: The limits of the nebula were traced as far as long and close examination could discern them, and a rough chart was made of the principal stars within it. This preparation was indispensable, because, in the consequent mapping down of all the visible stars in the nebula, it was necessary to use a light out-of-doors, and the object, of course, became invisible. The distance between any two conspicuous stars favorably situated in the nebula was then chosen as a standard of reference; and, from this as a base, a kind of triangulation was carried out by the eye to all the stars in the neighborhood, and these were successively marked on a sheet of paper at the time; their magnitudes were also affixed to each according to a fictitious scale, for which a few stars, conveniently situated, furnished standards of reference as to size. A lamp was close at hand, whose light could be cut off at pleasure; and almost direct comparison was thus instituted between the stars in the field of view and those on the paper, and corrections made where any distortions in the latter were observable. As the work advanced from night to night, the reference to the lamp was necessarily less and less direct, since a longer exclusion of light was necessary to see the fainter stars. Finally, the nebula itself was drawn upon the map by the guidance of the stars already

copied; and although only an occasional and unfrequent reference could be made to a lamp, the stars within it had become so familiar by their constant recurrence, that the memory could as easily as before retain its estimates of distance and direction, until mutual comparison could be made between the map and the heavens."

It will be seen what a great advance had been made in the conception of the application of the topographical method of contour lines to the delineation of degrees of brightness, although this method has practical limitations not spoken of by Mason, and we must consider the careful separation of the various results into classes ranged according to their degrees of certainty, as scarcely less important. In all former memoirs the chart included *all* the results reached, and there was no searching division of these in such a way as to give absolute data to the future investigator.

Throughout the entire memoir (which relates also to other nebulæ than the one now in question) the whole endeavor is to reach a perfect *definiteness* of conception; and Mason evidently held the idea that, in the existing state of astronomy, it was eminently "better to do one thing well than many things indifferently."

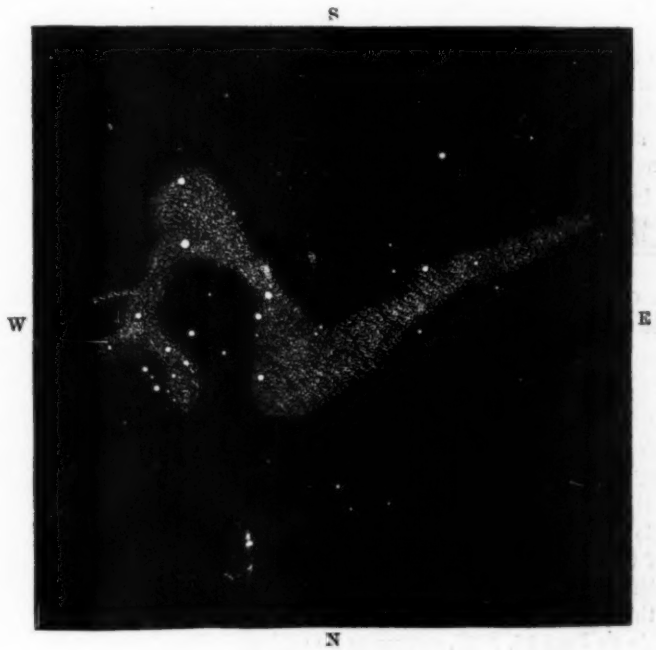


FIG. 4.—LAMONT, 1837.

Lamont tells us in *Annalen der K. Sternwarte bei München*, Band xvii. (1868), that his early researches on this and other nebulæ were prosecuted in the hope that something might be determined as to their

real nature, and he expresses his opinion that all nebulæ consist essentially of clusters of stars, more or less remote. His original researches were published in 1837, accompanied by figures, and they are of high authority on this subject. We give Lamont's figure above. These two drawings having been executed by different observers with different telescopes (Lamont's refractor of nine inches aperture, and Mason's reflector of twelve inches) will afford in the cases in which they agree indubitable evidence as to the *existence* of any feature shown in them. The *non-existence* of any feature not shown in either is probable, although not *certain*.

Sir John Herschel's "Results of Astronomical Observations at the Cape of Good Hope" was published in 1847, and his drawing (our Fig. 2), in the order of publication, belongs *after* Fig. 4.

In his first paper he describes Fig. 1 as follows:

"The figure of this nebula is nearly that of a Greek capital omega, Ω, somewhat distorted, and very unequally bright. It is remarkable that this is the form usually attributed to the great nebula in Orion, though in that nebula I confess I can discern no resemblance whatever to the Greek letter. Messier perceived only the bright eastern branch of the nebula now in question, without any of the attached convolutions which were first noticed by my father. The chief peculiarities which I have observed in it are—1. The resolvable knot in the eastern portion of the bright branch, which is, in a considerable degree, insulated from the surrounding nebula; strongly suggesting the idea of an absorption of the nebulous matter; and, 2. The much feebler and smaller knot at the northwestern end of the same branch, where the nebula makes a sudden bend at an acute angle. With a view to a more exact representation of this curious nebula, I have at different times taken micrometrical measures of the relative places of the stars in and near it, by which, when laid down as in a chart, its limits may be traced and identified, as I hope soon to have better opportunity to do than its low situation in this latitude will permit."

This opportunity was afforded him at his southern station, and his Fig. 2 is accordingly much more detailed. He says of it in the work last cited that his Fig. 1 is far from an accurate expression of its shape:

"In particular the large horseshoe-shaped arc . . . is there represented as too much elongated in a vertical direction and as bearing altogether too large a proportion to [the eastern] streak and to the total magnitude of the object. The nebulous diffusion, too, at the [western] end of that arc, forming the [western] angle and base-line of the capital Greek omega (Ω), to which the general figure of the nebula has been likened, is now so little conspicuous as to induce a suspicion that some real change may have taken place in the relative brightness of this portion compared with the rest of the nebula; seeing that a figure of it made on June 25, 1837, expresses no such diffusion, but represents the arc as breaking off before it even attains fully to the group of small stars at the [western] angle of the Omega. . . . Under these circumstances the arguments for a real change in the nebula might seem to have considerable weight. Nevertheless, they are weakened or destroyed by a contrary testimony entitled to much reliance. Mr. Mason, a young and ardent astronomer, ... whose pre-

mature death is the more to be regretted, as he was, so far as I am aware, the only other recent observer who has given himself with the assiduity which the subject requires to the exact delineation of nebulæ, and whose figures I find at all satisfactory, expressly states that *both* the nebulous knots were well seen by himself and his coadjutor Mr. Smith on August 1, 1839, i. e., two years subsequent to the date of my last drawing. Neither Mr. Mason, however, nor any other observer, appears to have had the least suspicion of the existence of the fainter horseshoe arc attached to the [eastern] extremity of Messier's streak. Dr. Lamont has given a figure of this nebula, accompanied by a description. In this figure [our Fig. 4], the nebulous diffusion at the [western] angle and along the [western] base-line of the Omega is represented as very conspicuous; indeed, much more so than I can persuade myself it was his intention it should appear."

When Lassell mounted his great four-foot reflector at Malta, he devoted much of his time to a systematic review of those nebulæ which had previously been figured either by himself or by Rosse and

FIG. 5.—LASSELL, 1862.

others, and, as was expected from the excellence of the climate, the superiority of the great telescope and the skill of the observer, this series of drawings at once took its place among the acknowledged classics on this subject. Too much praise can hardly be given to Lassell for confining his attention principally to objects previously figured, and for resisting the temptation to roam in those fields which

his own telescope had opened with its list of six hundred *new* nebulæ. And it may be remarked in passing that it is just this intelligent devotion to a definite aim and object which, in this case as in all, has led to brilliant results. We give Lassell's figure above, remarking that it was constructed, as indeed all the preceding ones had been, by first measuring the relative position of the brighter stars, then inserting by careful eye estimates the fainter ones, and finally by drawing among these stars, guided by their configurations, the details of the nebula itself.

Another, and a very rapid method of drawing nebulæ, is the following. It yields to the first in the accuracy of the positions of the stars, but it is probably even superior to it in facilities for the correct representation of the nebula and stars considered as one mass. A piece of glass is ruled carefully into squares (*see* Figs. 6 and 7) and this is placed in the focus of the telescope so as to be plainly visible; the telescope is then directed upon the nebula, and a clock-work motion is applied to the telescope so that it follows the apparent motion of the nebula from east to west accurately. Some one of the brighter stars is chosen, and it is kept by means of the clock-work accurately in the corner of one of the squares. A piece of paper ruled into squares similar to those of the glass reticle is provided, and on it the observer dots down the various stars in and about the nebula. This may take two, three, or four nights according to circumstances, but in all cases it requires much less time than the micrometric measurements of the brighter stars and the troublesome allineations required to fix the positions of the smaller stars, and it has the great advantage that the work can be done in a perfectly dark field of view, whereas the micrometric measures demand the use of illuminated wires at least. After the stars are inserted, the principal lines are put in, not only by the star-groups, but also by the squares themselves. For my own use I have had constructed two reticles: one ruled in squares like those seen in Figs. 6 and 7, and another in which the heavy-lined large squares (each containing nine small squares, *see* Fig. 6) are still present, but are subdivided into small squares by lines parallel to their own diagonals. After making all the use possible of the first reticle, the second is put in, and an entirely new set of reference-lines is obtained, making an angle of 45° with the old set. This, of course, could be equally obtained by revolving the first reticle through an angle of 45°, but it is not quite so convenient.

After the stars and the principal lines of the nebula are inserted a new and higher power eye-piece is used, and the drawing is concluded by means of this. Fig. 6 is an example of a drawing of the Horseshoe Nebula made in this way by M. Trouvelot, of Cambridge, Massachusetts, the artist to whom we owe the exquisite plates of astronomical engravings published by Harvard College Observatory, under the superintendence of its late director, Prof. Winlock.

During the last summer M. Trouvelot was invited by the superintendent of the United States Naval Observatory to visit Washington for the purpose of making drawings of nebulæ, etc., by means of the twenty-six inch Clark refractor. By the courtesy of Admiral Davis

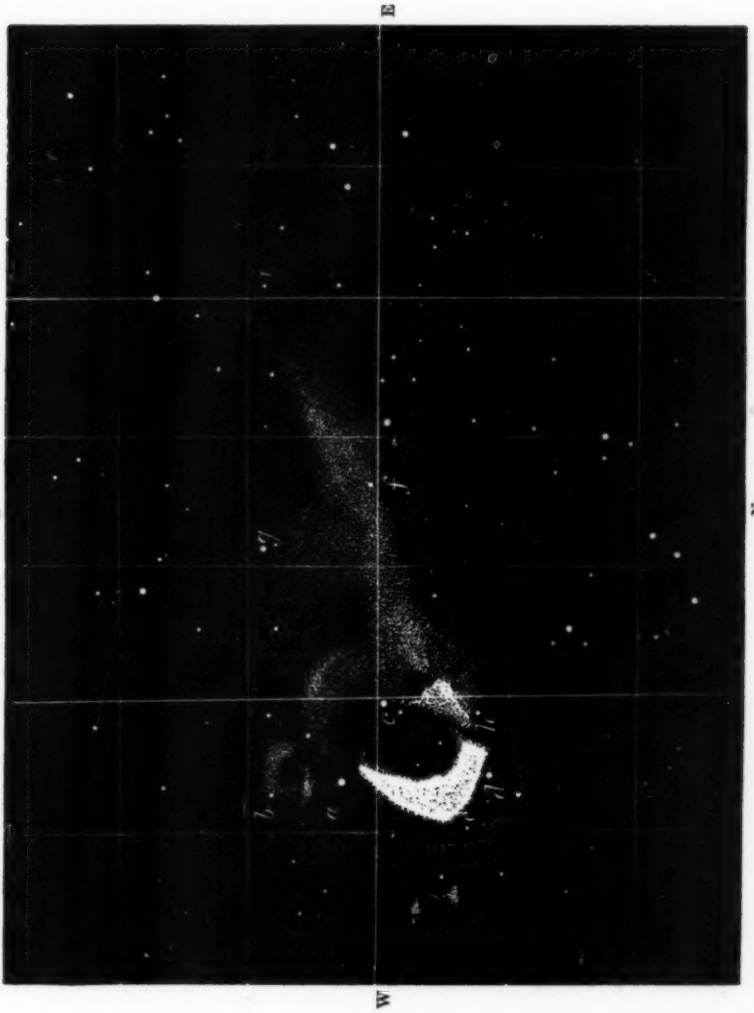


Fig. 6.—Trouvelot, 1875 (with a 6¼-inch Refractor).

I am able to give a drawing of the Horseshoe Nebula as delineated by M. Trouvelot from observations made jointly by him and by myself.

Pretty much the same method was adopted in this drawing as in Fig. 6, but the vastly more complex structure of the nebula itself is what might have been expected from an increase of eighteen times in the light, over M. Trouvelot's six-inch telescope.

From careful comparisons of different kinds, it has been found that the power of the Washington telescope is about the same as that of Lassell's great four-foot reflector, and the two drawings, Figs. 5 and 7, are therefore nearly comparable, i. e., almost as if made with the

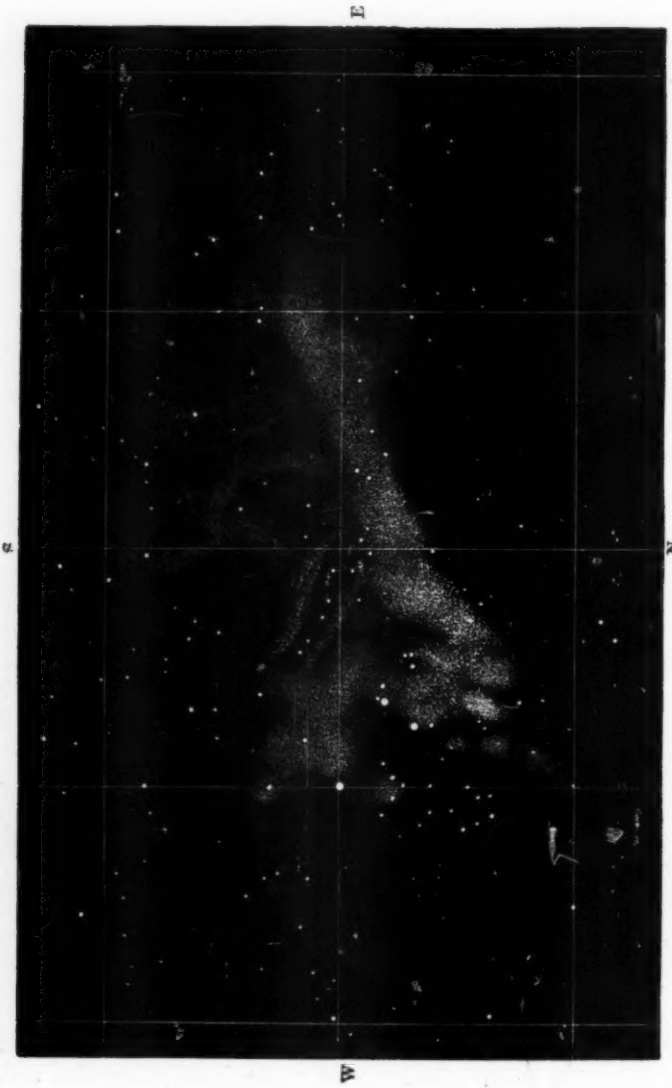


FIG. 7.—TROUVELOT, NAVAL OBSERVATORY, 1875 (26-INCH TELESCOPE).

same telescope at different times. It may be said of the last drawing that nothing is there laid down about which the slightest doubt is entertained; and although, in some respects, it was made in greater haste than is desirable, yet it is sufficiently accurate to found an argu-

ment on, for or against variation in the shape of any of the brighter portions of the nebula.

It is hoped that enough has been said to show how much care, skill, and patience, have been spent upon these drawings, and to show, too, how important are the conclusions which may be drawn from them. Their careful discussion involves considerations which might be out of place here, but which are well worth general attention. A full explanation of different methods has been given in the hope that some of the large telescopes in various parts of the United States in the hands of private gentlemen may be devoted to work of this class, in which it is easy for an amateur, with but a trifling expenditure of time and labor, to produce valuable results. Provided only that the work be done conscientiously and faithfully, it will be a definite gain to astronomy; without such care and fidelity, it will only introduce new confusion.

SCIENCE-TEACHING IN ENGLISH SCHOOLS.

By Rev. W. TUCKWELL.

THREE times within the last twelve years a royal commission has reported on the science-teaching of our higher schools. In 1864 the Public Schools Commission announced that from the largest and most famous schools of all it was practically excluded. In 1868 the Endowed Schools Commission declared that the majority of school-teachers had accepted it as part of their school-work. The Science Commissioners of 1875, in their sixth report, on "Science-Teaching in Schools," testing this statement by inquiry, state that of 128 endowed schools examined by them not one-half has even attempted to introduce it, while of these only 13 possess a laboratory, and only 10 give to the subject as much as four hours a week. And this statement is curiously illustrated by the statistics of the recent Oxford and Cambridge school examination, which show that out of 461 candidates for certificates, from 40 first-class schools, while 438 boys took up Latin, 433 Greek, 455 elementary mathematics, 305 history, only 21 took up mechanics, 28 chemistry, 6 botany, 15 physical geography.

In a volume whose research and condensation make it not only a monument of conscientious toil, but an invaluable hand-book to all who are laboring to work out practically the great problem of which it treats, the commissioners investigate the obstacles which have caused the endowed schools to defy the weighty recommendations of former commissions, the unanimous verdict of educational authorities outside the scholastic profession, and the increasingly urgent demands of English public opinion. They find the school-masters' excuses to be threefold: absence of funds, want of time, and skepti-

cism as to the educational value of science in comparison with other subjects. A large portion of the appendix is devoted to the consideration of these difficulties; to sifting the allegations on which they rest, and to balancing against them the experience of those teachers who have faced and successfully met them. Showing in detail the comparatively trifling cost at which indispensable apparatus can be obtained, the commissioners nevertheless admit the rarity, in the present state of English culture, either of independent science-teachers suited to the larger schools, or of men, such as poorer schools desiderate, combining literary with scientific knowledge. This, however, is an evil of the past rather than of the future, since not the least among the advantages expected from a reformed system of school-teaching is the creation of a race of able teachers, general as well as special. The relative value of science as an implement of mental training is next discussed. Its peculiar excellence is briefly vindicated, as cultivating, in a way attainable by no other means, the habits of observation and experiment, of classification, arrangement, method, judgment; and its suitability to the capacities of the very youngest boys is testified to by Faraday, Hooker, Rolleston, Carpenter, and Sir W. Thomson. Lastly, it is shown that, if this be so, the argument from want of time is no argument at all; that the hours are already wasted which condemn the half of a boy's faculties to stagnation, and render education one-sided and incomplete; and that the claims of different branches of instruction may be easily adjusted by economy of time, improvement in methods, and excision of superfluous studies.

On a review of all these objections and of the answers offered to them, and taking into account the dicta of former commissioners and the practice of other countries, the report advises that literature, mathematics, and science, should be the accepted subjects of education up to the time at which boys leave school, and should all three be made compulsory in any school-leaving-examination or university matriculation; but that after entering the university students should be left to choose for themselves among these lines of study, and need pass no subsequent examination in subjects other than the one which they select. As regards the teaching of science, they recommend that it should commence with the beginning of the school career; that not less than six hours a week should be devoted to it, and that in all school examinations as much as one-sixth of the marks should be allotted to it.

These recommendations possess the two great excellences of authoritativeness and clearness. They are supported by a host of experienced witnesses, as well as by the eminent names whose signatures follow them. Their ideal of school education is simplicity itself. The supremacy of classics is to be dethroned; the artifices of stratification and bifurcation are to be discarded; literature, mathematics, and science are to share a boy's intellect between them from the very first,

until a leaving-examination which shows his progress to have been satisfactory in all three sets him free to follow his inclination by pursuing exclusively the subject which suits him best; happy since eminence in that one will not have been purchased by entire ignorance of all the others. Unfortunately, though most necessarily—for this report concerns schools only—the curtain drops upon this interesting moment of transition, shutting out of view the influence which university scholarships and exhibitions exercise upon school-work, and thus ignoring an obstacle to the realization of the programme far greater than want of money, want of time, or want of appreciation, in the schools themselves.

What is the avowed object and purpose of the higher English school education? Is it the even and progressive development of young minds? the strengthening in equal proportion of the faculties of imagination, memory, reason, observation? the opening doors of knowledge in the plastic time of youth, which if not opened then will be fast closed in later years by the pressure of active work, or habitual exclusiveness, or energies paralyzed through disuse? Nothing of the kind. It is constructed entirely with the aim of winning certain prizes; for scholarships with which a costly university bribes men to come to it for education; for class-lists leading up to college fellowships; for the lucrative posts of military and civil service. In all these, but most of all where the universities can determine the ordeal, one principle of success has been established, and that principle is one-sidedness. The candidate for India, for Woolwich, for Cooper's Hill, must at an early age select certain subjects and throw overboard all the rest. The childish aspirant to the entrance scholarships of a public school is placed in the hands of a crammer at eight years old, that at thirteen he may turn out Latin verses as a Buddhist prayer-mill turns out prayers, and may manifest, as a distinguished head-master has lately said, to the eye of a teacher searching for intelligence, thoughtfulness, promise, intenseness, "a stupidity which is absolutely appalling." His scholarship won, he is pledged to pursue a course whose benefits are tangible and its evil consequences remote. The universities have stamped upon all the schools one deep certainty, that for a boy to be "all around," as it is called, is the irremissible sin; that a school-master who teaches with reference to intellectual growth and width of culture sacrifices thereby all hope of the distinctions which make a school famous and increase its numbers. If a classical scholarship is desired, science and mathematics are abandoned: nay, the palm of literary excellence is conceded even to men ignorant of the noblest literature in the world, their own birthright and inheritance, and knowing less of the history and structure of the English language than a fourth-form boy knows of Greek. If mathematical success is aimed at, literature and science are ignored; if the few science scholarships existing tempt candidates from any of "the thirteen schools

which possess a laboratory," mathematics in part and literature altogether must be given up. It would be waste of words to point out the fatal tendency of this separative process; to show how mere linguistic training needs the rationalizing aid of scientific study, or how exclusive science hardens and materializes without the refining society of literature; yet such divorce is inevitably due not to the convictions of school-masters, not to the influence of parents, not to the prepossessions of the public, but to the irresistible force of the university system, which makes narrowness of intelligence and imperfect knowledge the only avenues to distinction or to profit.

It is true that an attempt to alter this involves little short of a revolution; but by all accounts a revolution is at hand. It is not for nothing that a parliamentary investigation into the expenditure of college endowments should have been supported by members of the colleges themselves, or that a proposal to distribute college scholarships and exhibitions by a central authority in accordance with the results of the leaving-examination should have emanated from eminent university teachers. For it cannot be too strongly urged that college scholarships stand on very different ground from university prizes or degrees. It is easy for Parliament to lay down rules which shall control the latter once for all; it is not easy to bind the actions of some forty different foundations, each electing its own scholars according to its own idiosyncrasies, or in obedience to the changing wills of bodies in a perpetual state of flux. It may still be audacious, but it is no longer novel, to suggest that, supposing future legislation to retain the college scholarships at all, they should be awarded by the authority of government, in strict connection with leaving-examinations which government shall conduct, and in reward not of special but of general proficiency. For this the scheme of the commissioners virtually contends; into regions beyond this the report before us necessarily does not enter.

It will be seen that we accept, and recommend all teachers to accept, the scheme of the commissioners unreservedly as a working basis of educational improvement. It may not be ideally perfect; it may invite opposition on points of detail; but it is the resultant of all the intellectual forces which have hitherto been brought to bear upon the subject; and, while agreeing with all its witnesses on the principle that wide general training should precede specialization of study, it attains extreme simplicity of arrangement by allotting the first of these to the schools and the last to the universities. Do not let us forget that the cry which has arisen hitherto from all the head-masters on the point of scientific teaching has been a cry for guidance; for commanding and intelligent leadership; for authoritative enlightenment as to the relative value and the judicious sequence of scientific subjects; for information as to text-books, apparatus, teachers. For the first time this cry is met by an oracle whose authority no one will

question, and whose completeness of delivery all who study its utterances will appreciate. School-masters anxious to teach science, and doubtful how to set about it, will meet all the facts which can enlighten them in the appendices to the report. They will find lists of accredited text-books, specimens of examination-papers, varieties of school time-tables, priced catalogues of apparatus, syllabi of lectures and experiments, botanical schedules and tables, plans and descriptions of laboratories, workshops, museums, botanic gardens; programmes and reports of school, scientific, and natural history societies. They will learn how costly a temple could be built to science at Rugby, and how modestly it could be housed at Taunton. They will see how Mr. Foster teaches physics, how Mr. Hale teaches geography, how Mr. Wilson teaches *Erdkunde*. And they will accept all this as coming from men who have a right to speak, and who wield an experience such as has not been amassed before. On any legislative change which impends over the system and the endowments of the higher English education, the body of scientific opinion is strong enough, if united, to impress its own convictions; disunion alone can paralyze it. All who feel the discredit of past neglect, its injury to our national intellect, and its danger to our national prosperity, will do well to support by unqualified adhesion the first attempt that has been made to probe its causes, and the first consistent and well-considered scheme that has been put forth for its removal.—*Nature*.

MODERN BIOLOGICAL INQUIRY.

By Dr. JOHN L. LE CONTE.

THE founders of science in America, and the other great students of Nature, who have in previous years occupied the elevated position in which I now stand, have addressed you upon many momentous subjects. In fulfilling the final duty assigned to your Presidents by the laws of the Association, some have spoken to you in solemn and wise words concerning the duties and privileges of men of science, and the converse duties of the nation toward those earnest and disinterested promoters of knowledge. Others, again, have given you the history of the development of their respective branches of study, and their present condition, and have, in eloquent diction, commended to your gratitude those who have established on a firm foundation the basis of our modern systems of investigation.

The recent changes in our constitution, by which you are led to

[1] Address of the retiring President delivered at the Detroit meeting of the American Association for the Advancement of Science.

expect from your two Vice-Presidents, and from the chairman of the Chemical Subsection, addresses on the progress made during the past year, restrain me from invading their peculiar fields of labor, by alluding to scientific work which has been accomplished since our last meeting. While delicacy forbids me from so doing, I am equally debarred from repeating to you the brief sketch I endeavored to give at a former meeting,[1] of the history and present condition of entomology in the United States.

But it has appeared to me that a few thoughts, which have impressed themselves on my mind, touching the future results to be obtained from certain classes of facts, not yet fully developed, on account of the great labor required for their proper comparison, may not be without value. Even if the facts be not new to you, I hope to be able, with your kind attention, to present them in such way as to be suggestive of the work yet to be done.

It has been perhaps said, or at least it has been often thought, that the first mention of the doctrine of evolution, as now admitted to a greater or less degree by every thinking man, is found in Ecclesiastes i. 9:

"The thing that hath been, is that which shall be: and that which is done, is that which shall be done: and there is no new thing under the sun. Is there any thing whereof it may be said, See, this is new? It hath been already of old time, which was before us."

Other references to evolutionary views in one form or another occur in the writings of several philosophers of classic times, as you have had recent cause to remember.

Whether these are to be considered as an expression of a perfect truth in the very imperfect language which was alone intelligible to the nation to whom this sacred book was immediately addressed on the one hand, and the happy guesses of philosophers, who by deep intuition had placed themselves in close sympathy with the material universe, on the other hand, I shall not stop to inquire. The discussion would be profitless, for modern science in no way depends for its magnificent triumphs of fact and thought upon any utterances of the ancients. It is the creation of patient, intelligent labor of the last two centuries, and its results can be neither confuted nor confirmed by any thing that was said, thought, or done, at an earlier period. I have merely referred to these indications of doctrines of evolution to recall to your minds that the two great schools of thought, which now divide philosophers, have existed from very remote times. They are, therefore, in their origin, probably independent of correct scientific knowledge.

You have learned from the geologists, and mostly from those of

[1] Proceedings of the American Association for the Advancement of Science, Section xxi. (Portland).

the present century, that the strata of the earth have been successively formed from fragments more or less comminuted by mechanical action, more or less altered by chemical combination and molecular rearrangement. These fragments were derived from strata previously deposited, or from material brought up from below, or even thrown down from above, or from the *débris* of organic beings which extracted their mineral constituents from surrounding media. Nothing new has been added, every thing is old; only the arrangement of the parts is new, but in this arrangement definite and recognizable unchanged fragments of the old frequently remain. Geological observation is now so extended and accurate that an experienced student can tell from what formation, and even from what particular locality, these fragments have been derived.

I wish to show that this same process has taken place in the organic world, and that by proper methods we can discover in our fauna and flora the remnants of the inhabitants of former geologic times, which remain unchanged, and have escaped those influences of variation which are supposed to account for the differences in the organic beings of different periods.

Should I succeed in this effort, we shall be hereafter enabled, in groups of animals which are rarely preserved in fossil condition, to reconstruct, in some measure, the otherwise extinct faunæ, and thus to have a better idea of the sequence of generic forms in time. We will also have confirmatory evidence of certain changes which have taken place in the outline of the land and the sea. More important still, we will have some indications of the time when greater changes have occurred, the rock evidence of which is now buried at the bottom of the ocean, or perhaps entirely destroyed by erosion or separations. Of these changes, which involved connections of masses of land, no surmise could be made, except through evidence to be gained in the manner of which I am about to speak.

My illustrations will naturally be drawn from that branch of zoölogy with which I am most familiar; and it is indeed to your too partial estimate of my studies in that science that I owe the privilege of addressing you on the present occasion.

There are, as you know, a particular set of Coleoptera which affect the sea-shore; they are not very numerous at any locality, but among them are genera which are represented in almost every country of the globe. Such genera are called cosmopolitan, in distinction to those which are found only in particular districts. Several of these genera contain species which are very nearly allied, or sometimes in fact undistinguishable and therefore identical along extended lines of coast.

Now, it happens that some of these species, though they never stray from the ocean-shore inland, are capable of living upon similar beaches on fresh-water lakes, and a few are found in localities which are now quite inland.

To take an example, or rather several examples together, for the force of the illustration will be thereby greatly increased.

Along the whole of the Atlantic, and the greater part of the Pacific coast of the United States, is found in great abundance, on sand-beaches, a species of tiger-beetle, *Cicindela hirticollis*, an active, winged, and highly-predaceous insect; the same species occurs on the sand-beaches of the Great Lakes, and, were it confined to these and similar localities, we would be justified in considering it as living there in consequence solely of the resemblance in the conditions of existence. But, it is also found, though in much less abundance, in the now elevated region midway between the Mississippi and Rocky Mountains. Now, this is the part of the continent which, after the division of the great intercontinental gulf in Cretaceous times, finally emerged from the bed of the sea, and was in the early and middle Tertiary converted into a series of immense fresh-water lakes. As this insect does not occur in the territory extending from the Atlantic to beyond the western boundary of Missouri, nor in the interior of Oregon and California, I think that we should infer that it is an unchanged survivor of the species which lived on the shores of the Cretaceous ocean, when the intercontinental gulf was still open, and a passage existed, moreover, toward the southwest, which connected with the Pacific.

The example I have given you of the geographical distribution of *Cicindela hirticollis* would be of small value, were it an isolated case; nor would I have thought it worthy of occupying your time, on an occasion like this, which is justly regarded as one for the communication of important truth. This insect, which I have selected as a type for illustrating the methods of investigation to which I invite your attention, is, however, accompanied more or less closely by other Coleoptera, which like itself are not particular as to the nature of their food, so long as it be other living insects, and apparently are equally indifferent to the presence of large bodies of salt-water. First, there is *Cicindela lepida*, first collected by my father, near Trenton, New Jersey, afterward found on Coney Island, near New York, and received by me from Kansas and Wisconsin; not, however, found west of the Rocky Mountains. This species, thus occurring in isolated and distant localities, is probably in process of extinction, and may or may not be older than *C. hirticollis*. I am disposed to believe, as no representative species occurs on the Pacific coast, and from its peculiar distribution, that it is older. Second, there is *Dyschirius pallipennis*, a small Carabide, remarkable among other species of the genus by the pale wing-covers, usually ornamented with a dark spot. This insect is abundant on the Atlantic coast, from New York to Virginia, unchanged in the interior parts of the Mississippi Valley, represented at Atlantic City, New Jersey, by a larger and quite distinct specific form, *C. sellatus*, and on the Pacific coast by two or three species of larger size and different shape, which in my less experienced youth I

was disposed to regard as a separate genus, *Akephorus*. This form is, therefore, in a condition of evolution—how, I know not—our descendants may. The Atlantic species are winged; the Pacific ones, like a large number of insects of that region, are without wings.

Accompanying these are Coleoptera of other families, which have been less carefully studied, but I will not trespass upon your patience by mentioning more than two. *Bledius pallipennis* (*Staphylinidæ*) is found on salt marshes near New York, on the Southern sea-coast, and in Kansas; *Ammodonus fossor*, a wingless Tenebrionide, Trenton sea-shore near New York, and valley of the Mississippi at St. Louis; thus nearly approximating *Cicindela lepida* in distribution.

We can thus obtain by a careful observation of the localities of insects, especially such as affect sea-shore or marsh, and those which, being deprived of their favorite surroundings, have shown, if I may so express myself, a patriotic clinging to their native soil, most valuable indications in regard to the time at which their unmodified ancestors first appeared upon the earth. For it is obvious that no tendency to change in different directions by "numerous successive slight modifications" [1] would produce a uniform result in such distant localities, and under such varied conditions of life. Properly studied, these indications are quite as certain as though we found the well-preserved remains of these ancestors in the mud and sand strata upon which they flitted or dug in quest of food.

Other illustrations of survivals from indefinitely more remote times I will also give you, from the Coleopterous fauna of our own country, though passing time admonishes me to restrict their number.

To make my remarks intelligible, I must begin by saying that there are three great divisions of Coleoptera, which I will name in the order of their complication of structural plan: 1. Rhynchophora; 2. Heteromera; 3. Ordinary or normal Coleoptera; the last two being more nearly allied to each other than either is to the first. I have in other places exposed the characters of these divisions, and will not detain you by repeating them.

From paleontological evidence derived from other branches of zoölogy, we have a right to suppose, if this classification be correct, that these great types have been introduced upon the earth in the order in which I have named them.

Now, it is precisely in the first and second series that the most anomalous instances of geographical distribution occur; that is to say, the same or nearly identical genera are represented by species in very widely-separated regions, without occurring in intermediate or contiguous regions. Thus there is a genus *Emeax*, founded by Mr. Pascoe, upon an Australian species, which, when I saw it, I recognized as belonging to *Nyctoporis*, a California genus, established many years before; and, in fact, barely specifically distinct from *N. galeata*.

[1] "Origin of Species," 1869, p. 227.

Two other examples are *Othnius* and *Eupleurida*, United States genera, which are respectively equivalent to *Elacatis* and *Ischalia*, found in Borneo. Our native genera *Eurygenius* and *Toposcopus* are represented by scarcely different forms in Australia. All these belong to the second series (*Heteromera*), and the number of examples might be greatly increased with less labor on my part than patience on yours.

A single example from the Rhynchophora, and I will pass to another subject.

On the sea-coast of California, extending to Alaska, is a very anomalous insect, whose affinities are difficult to discern, called *Emphyastes fucicola*, from its occurrence under the sea-weed cast up by the waves. It is represented in Australia by several species of a nearly allied genus, *Aphela*, found in similar situations.

In all entomological investigations relating to geographical distribution, we are greatly embarrassed by the multitude of species, and by the vague and opinionative genera founded upon characters of small importance. The Coleoptera alone, thus far described, amount to over 60,000 so-called species, and there are from 80,000 to 100,000 in collections. Under these circumstances it is quite impossible for one person to command either the time or the material to master the whole subject, and, from the laudable zeal of collectors to make known what they suppose to be new objects, an immense amount of synonymy must result. Thus in the great "Catalogus Coleopterorum" of Gemminger and Harold, a permanent record of the untiring industry of those two excellent entomologists, species of the genus *Trechicus*, founded by me upon a small North American insect, are mentioned under five generic names, only one of which is recognized as a synonym of another. These generic headings appear in such remote pages of the volume as 135, 146, and 289.

The two closely-allied genera of Rhynchophora mentioned above are separated by no less than 168 pages.

It is therefore plain that, before much progress can be made in the line of research which I have proposed to you, whereby we may recover important fragments of the past history of the earth, entomology must be studied in a somewhat different manner from that now adopted. The necessity is every day more apparent that descriptions of heterogeneous material are rather obstructive than beneficial to science, except in the case of extraordinary forms likely to give information concerning geographical distribution or classification. Large typical collections affording abundant material for comparison, for the approximation of allied forms, and the elimination of doubtful ones, must be accumulated, and, in the case of such perishable objects as those we are now dealing with, must be placed where they can have the protecting influences both of climate and personal care.

At the same time, for this investigation, the study of insects is peculiarly suitable; not only on account of the small size, ease of collecting, and little cost of preserving the specimens, but because from their varied mode of life in different stages of development, and perhaps for other reasons, the species are less likely to be destroyed in the progress of geological changes.[1] Cataclysms and submergences, which would annihilate the higher animals, would only float the temporarily asphyxiated insect, or the tree-trunks containing the larvæ and pupæ, to other neighboring lands. However that may be, I have given you some grounds for believing that many of the species of insects now living existed in the same form before the appearance of any living genera of mammals, and we may suppose that their unchanged descendants will probably survive the present mammalian fauna, including our own race.

I may add, moreover, that some groups, especially in the Rhynchophora, which, as I have said above, I believe to be the earliest introduced of the Coleoptera, exhibit with compact and definite limits, and clearly-defined specific characters, so many generic modifications, that I am compelled to think that we have in them an example of the long-sought, unbroken series, extending in this instance from early mesozoic to the present time, and of which very few forms have become extinct.

I have used the word *species* so often, that you will doubtless be inclined to ask, What, then, is understood by a species? Alas! I can tell you no more than has been told recently by many others. It is an assemblage of individuals, which differ from each other by very small or trifling and inconstant characters, of much less value than those in which they differ from any other assemblage of individuals. Who determines the value of these characters? The experienced student of that department to which the objects belong. Species are, therefore, those groups of individuals representing organic forms which are recognized as such by those who from natural power and education are best qualified to judge.

You perceive, therefore, that we are here dealing with an entirely different kind of information from that which we gain from the physical sciences; every thing there depends on accurate observation, with strict logical consequences derived therefrom. Here the basis of our knowledge depends equally on accurate and trained observation, but the logic is not formal but perceptive.

This has been already thoroughly recognized by Huxley[2] and

[1] For a fuller discussion of these causes, and of several other subjects which are briefly mentioned in this address, the reader may consult an excellent memoir by my learned friend Mr. Andrew Murray, "On the Geographical Relations of the Chief Coleopterous Faunæ."—(*Journal of Linnæan Society, Zoölogy*, vol. xi.)

[2] "A species is the smallest group to which distinctive and invariable characters can be assigned." ("Principles and Methods of Paleontology," Smithsonian Report, 1869, p. 378.)

Helmholtz,[1] and others, but we may properly extend the inquiry into the nature and powers of this æsthetic perception somewhat further. For it is to this fundamental difference between biological and physical sciences that I will especially invite your attention.

Sir John Lubbock,[2] quoting from Oldfield,[3] mentions that certain Australians "were quite unable to realize the most vivid artistic representations. On being shown a picture of one of themselves, one said it was a ship, another a kangaroo, not one in a dozen identifying the portrait as having any connection with himself."

These human beings, therefore, with brains very similar to our own, and, as is held by some persons, potentially capable of similar cultivation with ourselves, were unable to recognize the outlines of even such familiar objects as the features of their own race. Was there any fault in the drawing of the artist? Probably not. Or in the eye of the savage? Certainly not, for that is an optical instrument of tolerably simple structure, which cannot fail to form on the retina an accurate image of the object to which it is directed. Where, then, is the error? It is in the want of capacity of the brain of the individual (or rather the race in this instance) to appreciate the resemblance between the outline, the relief, the light and shade of the object pictured, and the flat representation in color: in other words, a want of "artistic tact" or æsthetic perception.

A higher example of a similar phenomenon I have myself seen: many of you too have witnessed it, for it is of daily occurrence. It is when travelers in Italy, having penetrated to the inmost chamber of the Temple of Art, even the hall of the Tribune at Florence, stand in presence of the most perfect works of art which it has been given to man to produce, and gaze upon them with the same indifference that they would show to the conceptions of mediocre artists exhibited in our shops.

Perhaps they would even wonder what one can find to admire in the unrivaled collection which is there assembled.

There is surely wanting in the minds of such persons that high, æsthetic sense, which enables others to enter into spiritual harmony with the great artists whose creations are before them.

Creations I said, and I use the word intentionally. If there is one power of the human soul which, more nearly than any other, ap-

[1] "I do not mean to deny that, in many branches of these sciences, an intuitive perception of analogies and a certain artistic tact play a conspicuous part. In natural history . . . . it is left entirely to this tact, without a clearly definable rule, to determine what characteristics of species are important or unimportant for purposes of classification, and what divisions of the animal or vegetable kingdom are more natural than others." ("Relation of the Physical Sciences to Science in General." Smithsonian Report, 1871, p. 227.)

[2] "Prehistoric Times," p. 440.

[3] "On the Aborigines of Australia." Transactions of Ethnological Society, New Series, vol. iii.

proaches the faculty of creation, it is that by which the almost inspired artist develops out of a rude block of stone, or out of such mean materials as canvas and metallic pastes of various colors, figures which surpass in beauty, and in power of exciting emotion, the objects they profess to represent.

Yet these unæsthetic and non-appreciative persons are just as highly educated, and in their respective positions as good and useful members of the social organism, as any that may be found. I maintain only, they would never make good students of biology.

In like manner, by way of illustrating the foregoing observations, there are some who, in looking at the phenomena of the external universe, may recognize only chance, or the "fortuitous concourse of atoms," producing certain resultant motions. Others, having studied more deeply the nature of things, will perceive the existence of laws, binding and correlating the events they observe. Others, again, not superior to the latter in intelligence, nor in power of investigation, may discern a deeper relation between these phenomena and the indications of an intellectual or æsthetic or moral plan, similar to that which influences their own actions, when directed to the attaining of a particular result.

These last will recognize in the operations of Nature the direction of a human intelligence, greatly enlarged, capable of modifying at its will influences beyond our control; or they will appreciate in themselves a resemblance to a superhuman intelligence which enables them to be in sympathy with its actions.

Either may be true in individual instances of this class of minds; one or other must be true; I care not which, for to me the propositions are in this argument identical, though in speculative discussions they may be regarded as at almost the opposite poles of religious belief. All that I plead for is, that those who have not this perceptive power, and who in the present condition of scientific discussion are numerically influential, will have tolerance for those who possess it; and that the ideas of the latter may not be entirely relegated to the domain of superstition and enthusiasm.

In the case of the want of perception of the Australian, a very simple test can be applied. It is only to photograph the object represented by the artist, and compare the outlines and shades of the photograph with those of the picture. If they accord within reasonable limits, the picture is correct to that extent; at least, however bad the artist, the human face could never be confounded with a ship or a kangaroo.

Can we apply a similar test to the works of Nature? I think we can. Suppose that man—I purposely use the singular noun to indicate that all human beings of similar intelligence and education working toward a definite end will work in a somewhat similar manner—suppose, then, I say, that man, endeavoring to carry out some object

of importance, devises a method of so doing, and creates for that purpose a series of small objects, and we find that these small objects naturally divide and distribute themselves in age and locality, in a similar manner to that in which the species of a group of organisms are divided in space, and distributed in time; and that the results of man's labor are thus divided and distributed on account of the necessary inherent qualities of his intelligence and methods of action—is not the resemblance between human reason and the greater powers which control the manifestations of organic Nature apparent?

I now simply present to you this investigation. Time is wanting for me to illustrate it by even a single example, but I feel sure that I have in the minds of some of you already suggested several applications of it to the principle I wish to teach: the resemblance in the distribution of the works of Nature to that of human contrivances evolved for definite purposes.

If this kind of reasoning commends itself to you, and you thus perceive resemblances in the actions of the Ruler of the universe to those of our own race, when prompted by the best and highest intellectual motives, you will be willing to accept the declaration of the ancient text, "He doeth not evil, and abideth not with the evil inclined. Whatever he hath done is good;"[1] or that from our own canon of Scripture: "With him is wisdom and strength, he hath counsel and understanding."[2]

The æsthetic character of natural history, therefore, prevents the results of its cultivation from being worked out with the precision of a logical machine, such as, with correct data of observation and calculation, would be quite sufficient to formulate the conclusions of physical investigation. According as the perception of the relations of organic beings among themselves becomes more and more enlarged, the interpretation of these relations will vary within limits; but we will be continually approximating higher mental or spiritual truth.

This kind of truth can never be revealed to us by the study of inorganic aggregations of the universe. The molar, molecular, and polar forces, by which they are formed, may be expressed, so far as science has reduced them to order, by a small number of simply formulated laws, indicative neither of purpose nor intelligence, when confined within inorganic limits. In fact, taking also the organic world into consideration, we as yet see no reason why the number of chemical elements known to us should be as large as it is, and go on increasing almost yearly with more minute investigations. To all appearance, the mechanical and vital structure of the universe would remain unchanged, if half of them were struck out of existence.

Neither is there any evidence of intelligence or design in the fact that the side of the moon visible to us exhibits only a mass of volcanoes.

[1] "Desatir," p. 2. [2] Job xii. 13

Yet upon the earth, without the volcano and the earthquake, and the elevating forces of which they are the feeble indications, there would be no permanent separation of land and water; consequently no progress in animal and vegetable life beyond what is possible in the ocean. To us, then, as sentient beings, the volcano and the earthquake, viewed from a biological stand-point, have a profound significance.

It is indeed difficult to see in what manner the student of purely physical science is brought to a knowledge of any evidences of intelligence in the arrangement of the universe. The poet, inspired by meditating on the immeasurable abyss of space and the transcendent glories of the celestial orbs, has declared—

"The undevout astronomer is mad,"

and his saying had a certain amount of speciousness, on account of the magnitude of the bodies and distances with which the student of the stars is concerned. This favorite line is, however, only an example of what an excellent writer has termed "the unconscious action of volition upon credence," and it is properly in the correlations of the inorganic with the organic world that we may hope to exhibit, with clearness, the adaptations of plan prefigured and design executed.

In the methods and results of investigation, the mathematician differs from both the physicist and the biologist. Unconfined, like the former, by the few simple relations by which movements in the inorganic world are controlled, he may not only vary the form of his analysis, almost at pleasure, making it more or less transcendental in many directions, but he may introduce factors or relations, apparently inconceivable in real existences, and then interpret them into results quite as real as those of the legitimate calculus with which he is working, but lying outside of its domain.

If biology can ever be developed in such manner that its results may be expressed in mathematical formulæ, it will be the pleasing task of the future analyst to ascertain the nature of the inconceivable (or imaginary as they are termed in mathematics) quantities which must be introduced when changes of form or structure take place. Such will be analytical morphology, in its proper sense; but it is a science of the future, and will require for its calculus a very complex algebra.

In the observation of the habits of inferior animals, we recognize many complications of action, which, though directed to the accomplishment of definite purposes, we do not entirely comprehend. They are, in many instances, not the result of either the experience of the individual, or the education of its parents, who in low forms of animals frequently die before the hatching of the offspring. These actions have been grouped together, whether simple or complex, as directed

by what we are pleased to call instinct, as opposed to reason. Yet there is every gradation between the two.

Among the various races of dogs, the companions of man for unnumbered centuries, we observe not only reasoning powers of a rather high order, but also distinct traces of moral sentiments, similar to those possessed by our own race. I will give no examples, for many may be found in books with which you are familiar. Actions evincing the same mental attributes are also noticed in wild animals which have been tamed. You will reply that these qualities have been developed by human education; but not so: there must have been a latent capacity in the brain to receive the education, and to manifest the results by the modification of the habits. Now, it is because we are vertebrates, and the animals of which I have spoken are vertebrates, that we understand, though imperfectly, their mental processes, and can develop the powers that are otherwise latent. Could we comprehend them more fully we would find, and we do find from time to time in the progress of our inquiries, that what was classed with instinct is really intellection.

When we attempt to observe animals belonging to another subkingdom—Articulata, for instance—such as bees, ants, termites, etc., which are built upon a totally different plan of structure, having no organ in common with ourselves, the difficulty of interpreting their intellectual processes, if they perform any, is still greater. The purposes of their actions we can only divine by their results. But any thing more exact than their knowledge of the objects within their scope, more ingenious than their methods for using those objects, more complex, yet well devised, than their social and political systems, it is impossible to conceive.

We are not warranted in assuming that these actions are instinctive, which if performed by a vertebrate we would call rational. Instead of concealing our ignorance under a word which thus used comes to mean nothing, let us rather admit the existence here of a rational power, not only inferior to ours, but also different.

Thus proceeding, from the highest forms in each type of animal life to the lower, and even down to the lowest, we may be prepared te advance the thesis that all animals are intelligent, in proportion to the ability of their organization to manifest intelligence to us or to each other; that wherever there is voluntary motion, there is intelligence: obscure it may be, not comprehended by us, but comprehended by the companions of the same low grade of structure.

However this may be, I do not intend to discuss the subject at present, but only wish in connection with this train of thought to offer two suggestions.

The first is, that by pursuing different courses of investigation in biology, we may be led to opposite results. Commencing with the simplest forms of animal life, or with the embryo of the higher ani-

mals, it may be very difficult to say at what point intelligence begins to manifest itself; our attention is concentrated, therefore, upon those functions which appear to be the result of purely mechanical arrangements, acted upon by external stimuli. The animal becomes to our perception an automaton, and in fact, by excising some of the nervous organs last developed in its growth, we can render an adult animal an automaton, capable of performing only those habitual actions to which its brain, when in perfect condition, had educated the muscles of voluntary motion. On the other hand, commencing with the highest group in each type, and going downward, either in structural complication, or in age of individual, it is impossible to fix the limit at which intelligence ceases to be apparent.

I have in this subject, as in that of tracing the past history of our insects, in the first part of this address, preferred the latter mode of investigation; taking those things which are nearest to us in time or structure as a basis for the study of those more remote.

The second consideration is, since it is so difficult for us to understand the mental processes, whether rational or instinctive (I care not by what name they are called), of beings more or less similar but inferior to ourselves, we should exercise great caution when we have occasion to speak of the designs of one who is infinitely greater. Let us give no place to the crude speculations of would-be teleologists, who are, indeed, in great part, refuted already by the progress of science, which continually exhibits to us higher and more beautiful relations between the phenomena of Nature "than it hath entered into the mind of man to conceive." Let not our vanity lead us to believe that, because God has deigned to guide our steps a few paces on the road of truth, we are justified in speaking as if he had taken us into intimate companionship, and informed us of all his counsels.

If I have exposed my views on these subjects to you in an acceptable manner, you will perceive that, in minds capable of receiving such impressions, biology can indicate the existence of a creative or directive power, possessing attributes some of which resemble our own, and controlling operations which we may feebly comprehend. Thus far natural theology, and no further.

What, then, is the strict relation of natural history or biology to that great mass of learning and influence which is commonly called theology; and to that smaller mass of belief and action which is called religion?

Some express the relation very briefly, by saying that science and religion are opposed to each other; others, again, that they have nothing in common. These expressions are true of certain classes of minds; but the greater number of thinking and educated persons see that, though the ultimate truths taught by each are of quite distinct nature, and can by no means come in conflict, inasmuch as they have no point in common, yet so far as these truths are embodied in hu-

man language, and manipulated by human interest, they have a common dominion over the soul of man. According to the method of their government, they may then come into collision even as the temporal and spiritual sovereigns of Japan occasionally did, before the recent changes in that country.

In answering the query above proposed, it will be necessary to separate the essential truths of religion from the accessories of tradition, usage, and, most of all, organizations and interpretations which have in the lapse of time gathered around the primitive or revealed truth.

With the latter, the scientific man must deal exactly like other men—he must take it or reject it, according to his spiritual gifts; but he must not, whatever be his personal views, discuss it or assail it *as a man of science*, for within his domain of investigation it does not belong.

With regard to the accessories of traditions, interpretations, etc., our answer may be clearer when we have briefly reviewed some recent events in what has been written about as the conflict of religion and science. Some centuries ago, great theological disgust was produced by the announcement that the sun and not the earth was the centre of the planetary system. A few decades ago profound dissatisfaction was shown that the evidence of organic life on the planet was very ancient. Recently some annoyance has been exhibited because human remains have been found in situations where they ought not to have been, according to popularly received interpretations; and yet more recently much apprehension has been felt at the possible derivation of man from some inferior organism; an hypothesis framed simply because, in the present condition of intellectual advancement, no other can be suggested.

Yet all these facts, but the last, which still is an opinion, have been accepted, after more or less bitter controversy on both sides, and the fountain of spiritual truth remains unclouded and undiminished. New interpretations for the sacred texts supposed to be in conflict with the scientific facts have been sought and found without difficulty. These much-feared facts have, moreover, given some of the strongest and most convincing illustrations to modern exhortation and religious instruction.

Thus, then, we see that the influence of science upon religion has been beneficial. Scholastic interpretations founded upon imperfect knowledge, or no knowledge, but mere guess, have been replaced by sound criticism of the texts, and their exegesis in accordance with the times and circumstances for which they were written.

It must be conceded by fair-minded men of both sides that these controversies were carried on at times with a rudeness of expression and bitterness of feeling now abhorrent to our usages. The intellectual wars of those days partook of the brutality of physical war, and

the horrors of the latter, as you know, have been ameliorated only within very few years.

I fear that the unhappy spirit of contention still survives, and that there are yet a few who fight for victory rather than for truth. The deceptive spirit of Voltaire still buds forth occasionally; he who, as you remember, disputed the organic nature of fossil shells, because in those days of schoolmen their occurrence on mountains would be used by others as a proof of a universal Noachian deluge. The power of such spirits is fortunately gone for any potent influence for evil, gone with the equally obstructive influence of the scholastics with whom they formerly contended.

Since, then, there is no occasion for strict science and pure religion to be in conflict, how shall the peace be kept between them?

By toleration and patience—toleration toward those who believe less than we do, in the hope that they, by cultivation or inheritance of æsthetic perception, will be prepared to accept something more than matter and energy in the universe, and to believe that vitality is not altogether undirected colloid chemistry.

Toleration also toward those who, on what we think misunderstood or insufficient evidence, demand more than we are prepared to admit, in the hope that they will revise additional texts which seem to conflict, or may hereafter conflict, with facts deduced from actual study of Nature, and thus prepare their minds for the reception of such truths as may be discovered, without embittered discussions.

Patience, too, must be counseled. For much delay will ensue before this desired result is arrived at; patience under attack, patience under misrepresentation, but never controversy.

Thus will be hastened the time when the glorious, all-sufficient spiritual light, which, though given through another race, we have adopted as our own, shall shine with its pristine purity, freed from the incrustations with which it has been obscured by the vanity of partial knowledge, and the temporary contrivances of human polity.

So, too, by freely-extended scientific culture, may we hope that the infinitely thicker and grosser superstitions and corruptions will be removed which greater age and more despotic governments have accumulated around the less brilliant though important religions of our Asiatic Aryan relatives. These accretions being destroyed, the principal difficulty to the reception by those nations of higher spiritual truths will be obviated, and the intelligent Hindoo or Persian will not be tardy in recognizing, in the pure life and elevated doctrine of the sincere Christian, an addition to and fuller expression of religious precepts with which he is familiar. In this manner alone may be realized the hope of the philosopher, the dream of the poet, and the expectation of the theologian—a universal science and a universal religion, coöperating harmoniously for the perfection of man and the glory of his Creator.

THE SAND-BLAST.

By W. S. WARD.

PROF. WILLIAM P. BLAKE, in a communication "On the Grooving and Polishing of Hard Rocks and Minerals by Dry Sand," which appeared in the *American Journal of Science and Arts*, September, 1855, describes the phenomena observed by him in 1838, in the Pass of San Bernardino, California, as follows: "On the eastern declivities of the pass, the side turned toward the desert, the granite and associate rocks which form the sharp peak San Gorgonio extend down the valley of the pass in a succession of sharp ridges, which, being devoid of soil and of vegetation, stand out in bold and rugged outlines against the clear, unclouded sky of that desert-region. It was on these projecting spurs of San Gorgonio that the phenomena of grooving were seen; the whole surface of the granite over broad spaces was cut into long and perfectly parallel grooves and little furrows, and every portion of it was beautifully smoothed, and, though very uneven, had a fine polish." While contemplating these curious effects, the solution of the problem was presented. The wind was blowing very hard, and carried with it numerous little grains of sand. A closer examination disclosed the fact that the whole of the polished surface was enveloped in an atmosphere of moving sand, and it was through the grinding and rubbing of these minute but numberless quartz-atoms that the rough surfaces of these rocks had been made smooth, and the natural grooves deepened and polished. "Even quartz," he observed, "was cut away and polished; garnets and tourmaline were also cut and left with polished surfaces. . . . Whenever a garnet or a lump of quartz was imbedded in compact feldspar and favorably presented to the action of the sand, the feldspar was cut away around the hard mineral, which was thus left standing in relief above the general surface."

The traveler whose good fortune it is to visit our Western wonderland, will note among the many fingers in his guide-book one pointing in the direction of the now famous Monument Park. Entering a narrow valley bordered by mountain-walls, he will find himself gazing in wonderment at the rounded stone columns, rising about him in groups or singly, to a height ranging from ten to forty feet, and in many instances surmounted with grotesque cap-like coverings, that rest balanced upon the frail pinnacles of the rock-columns. An inquiry as to the causes of their existence, standing as they do in isolation on the surface of the valley low-lands, will elicit the reply that they were made by the wearing away of the surrounding rocks by sand, which, whirling about in water or air eddies, acted like chisels of the turner's lathe. Where the depressions were deepest there the

rocky strata were soft and yielding, and were the more readily cut away; but where the opposing surface was hard, as in the case of the black cap-pieces, the action was less rapid, and the reduction of the rock less decided. Glancing off from these, the whole force of the driving sand was projected against the strata immediately below, thus reducing it in size till there seems hardly circumference enough left to sustain the weight above.

FIG. 1.—SAND-CUT COLUMNS IN MONUMENT PARK.

So much for the observations of the geologist and explorer, made nearly half a century ago, and placed on record as forming but one of the many startling features of that wonderful region, but suggesting to the traveler little else than a reasonable theory by which to account for a hitherto mysterious class of physical phenomena. From this, the record of the student of Nature, we turn to a second record, more practical in character, and having a direct bearing upon the subject under review.

Whether the author or inventor of the modern sand-blast deserves any less credit for having had his idea anticipated in the workshops

of Nature, we will not say; certain it is, however, that the former work suggested the latter, though the prior claim does not seem to have been considered by the American Commissioner of Patents.

"On the 18th of October, 1870," we read, "letters-patent of the United States were granted to General B. C. Tilghman, of Philadelphia, for the cutting, grinding, etching, engraving, and drilling stone, metal, wood, or any hard substance, by means of a jet or blast of sand." We are also informed, from the same official source, that the inventor of the sand-blast process obtained his first hints from Nature, and, by means of a mechanism which is a marvel of simplicity, has been able to utilize this same force so as to make it render most efficient service in several departments of the applied arts.

It is the object of the present paper to describe and illustrate the invention known as the Tilghman Sand-Blast, an invention which, in simplicity of construction, and yet extent of application, has hardly an equal in the annals of the American Patent-Office. We are aware that this is a broad claim, when it is remembered that under the protection of the same authority the sewing-machine, reaper, and mower, positive-action loom, and a score or more of great mechanical devices, first saw the light. It is possible that there is that in the idea of the sand-blast which adds to its charm, and secured for it the admiring indorsement of Torrey, Tyndall, and other men of science; and yet a careful study of its principle, and an observance of its practical operation, seem to justify all and more than is claimed for it by the inventor or his distinguished indorsers.

If the reader will refer to the simple "claim" as given above, he will notice that it is proposed to accomplish the several results there named "by means of a *jet* or blast of sand." The italics are our own, and are now introduced since it is in this idea of a *jet* of sand that the first principle of the device rests; and, moreover, it was an attempt made by others to adopt this falling jet of sand that compelled the inventor to institute his first proceeding against infringement. With the legal history of the sand-blast, however, we have nothing to do, save as it concerns the general history of the invention and its progress. In order that the methods by which a simple falling column or stream of sand is made to do service as an engraver of glass and metal plates may be understood, attention is directed to Fig. 2, which may be described as follows:

A is a box, elevated as high above the engraver's table as the height of the ceiling will permit. When designed for several workmen, this box may be divided into compartments, as indicated, each compartment being filled with common quartz or sea-sand, of varying degrees of fineness. From the bottom of each division a metal tube, *c*, depends, reaching to within a few inches of the table below. A slide, *B*, serves to regulate or check the flow of the sand. Thus much for the simplest form of sand-blast. A word as to the manner of its operation; and

here, again, reference must be made to the original "claim," where it will be found that the operation of the blast is limited to the cutting, grinding, etc., of any *hard* substance. . It may be well to note the significance of this word *hard*, since in it lies the secret of the whole process. The substance upon which the sand acts must be a hard or brit-

FIG. 2.—DEVICE FOR ETCHING WITH SAND.

tle one, falling or being blown upon which, the angular sand-grains chip away minute portions, till at length the whole surface is reduced or scratched to any desired depth. Thus, if the plate which, as shown in the figure, be a glass one, and the workman wishes to engrave on it a flat design, he has only to protect the portions which are not to be acted upon, by a stencil made from rubber, soft iron, leather, or even paper, since, these substances not being *hard* or brittle, will not be affected by the descending blows of the sand-grains. This the workman has done, and by this means he has been able to depolish or grind the surface of the plate as indicated. Of the methods of constructing and applying these stencils, their variety and several uses, descriptions will be given as we advance.

From the use of a simple jet of falling sand, we pass on a step, and in Fig. 3 present the Tilghman Sand-blast Machine, in its original and complete form, all subsequent improvements having been made only with a view to some special form of service. The feature of this device, it will be observed, is the use of a blast of air or steam which shall be made to accelerate the falling of the sand through the tube, and thus cause each grain to act with additional force upon the opposing surface. If the reader will, by the aid of the illustration, observe closely the construction of this simple device, he will be able to comprehend, once for all, not only the novelty of the invention, but also its extreme simplicity.

Connected with a wooden box, supported on a shelf, as here indicated, is a flexible rubber tube, which in turn is attached at its lower end to an iron tube, that rises through the floor of a miniature wagon. This wagon rests on the roof of a box through which a slit is cut in the direction shown. Through this slit the iron tube passes, projecting into the box below. It is to the structure of this metal tube, or gun, as it is called, that attention is specially directed. As shown in the

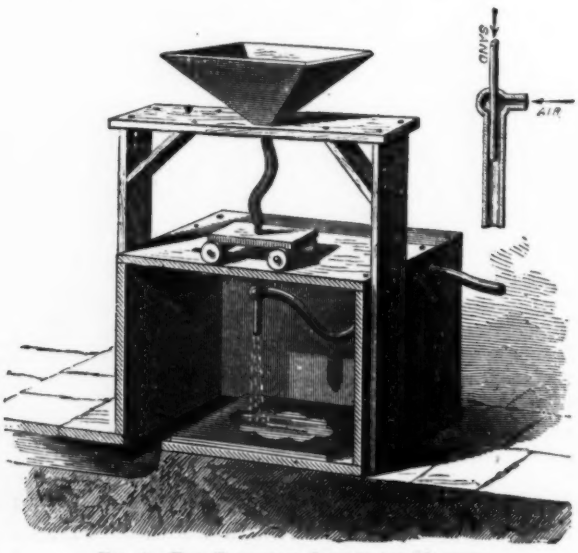


FIG. 3.—THE TILGHMAN SAND-BLAST MACHINE.

section at the right, it consists of two tubes, the one leading down from the box and conveying the sand being smaller, thus allowing of an annular space between it and the lower section. Into this lower section, and at a right angle to it, the blast of air is admitted from a suitable reservoir. The sand falling down, as shown by the upper arrow, enters the lower tube at a point below that at which the air is admitted. Having passed below the limits of its conducting-tube, it receives an extra impulse from the air-current that also is passing downward, and by it is projected with greater force upon the *hard* substance below. In addition to the advantage gained by this new impulse, it will also be seen that the blast serves another purpose in blowing away the sand, so soon as its work is done, and thus leaving the surface below clean and in a condition to be the more readily acted upon by the succeeding blasts. The purpose of the wagon is merely to admit of the tube being moved forward and backward along the line of the plate to be engraved, the lateral movement of the plate being effected by a suitable device not here shown. This plate is inclosed in a box, for the reason that the falling grains of sand, while they chip away the surface of the plate, are also broken up and pow-

dered. And it is that this dust may not interfere with the health and comfort of the workmen that the whole is confined in a closed box.

Before describing the several methods by which, through the aid of specially-prepared stencils, the surfaces to be treated are exposed to the action of the blast, we will direct attention to certain of the more recent forms of the machines, all embodying the same general principles, but so modified as to adapt them to the special service for which they are intended.

Foremost among these devices is the large machine, by the aid of which flat plates are ground or engraved.

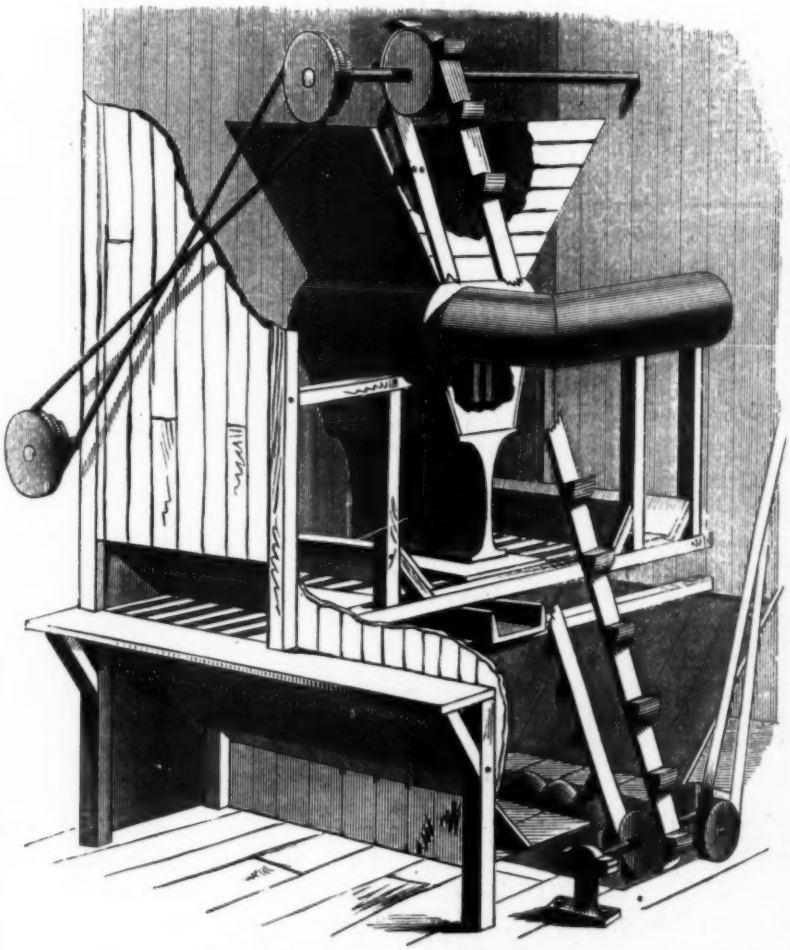


FIG. 4.—MACHINE FOR ENGRAVING FLAT PLATES.

The distinctive feature of this machine is the substitution of a long, narrow slit for the tube; through this the sand falls or is blown in a thin sheet. Referring to Fig. 4, we find the machine composed of a

large supply-box, into which the sand is elevated by a series of hoppers attached to a moving belt. From this box the sand falls of its own weight into a second receptacle, which serves also as a receiving-chamber for the air-blast that enters at the right through the large blast-pipe. From this receiver the sand is driven downward through a second slit, and emerges from it with great force.

At right angles with this slit a series of leather straps or moving belts serves to convey the polished plate beneath the sheet of falling sand, and it is during the passage of the plate under this sand-sheet that its surface is depolished or ground. As these plates move at the rate of from six to thirty inches a minute, an estimate can be made as to the rapidity with which the work of grinding is effected. When it is desired to merely roughen the whole surface, it is evident that no preliminary processes are needed, the plates of glass being fed in at the opening indicated on the right, and passing through to be received and delivered at once as ground glass.

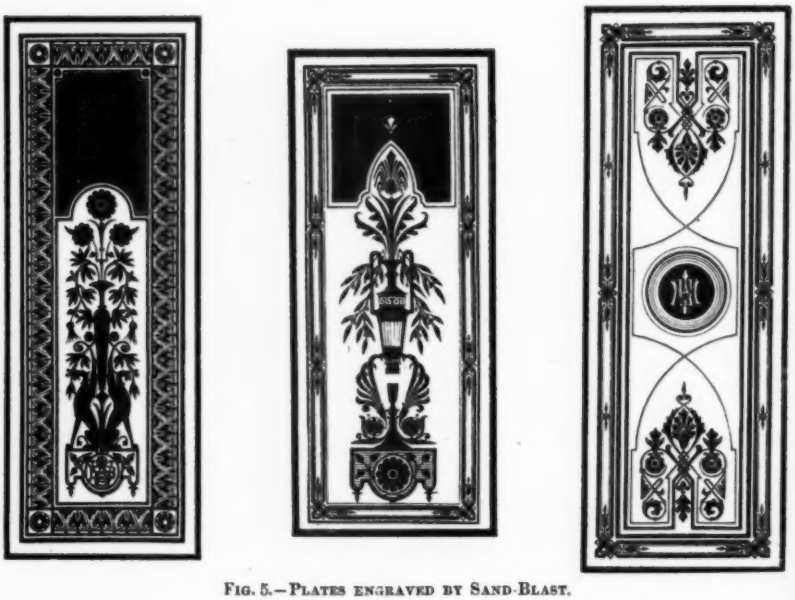


FIG. 5.—PLATES ENGRAVED BY SAND-BLAST.

When it is desired, however, to engrave figures or designs upon the plates, a special process precedes the grinding. This consists in the designing and attaching of the stencils, and may be described as follows: The glass plate, which it is proposed to ornament with any suitable device, is laid upon the designer's table and covered over its whole surface with a thin sheet of tin-foil. Upon this bright metallic surface the designer sketches his pattern, and then by the aid of a sharp knife-point cuts through the foil along the lines of the pattern. The foil, which indicates the design, is then carefully lifted and re-

moved, leaving the glass exposed, showing the exact form of the pattern. The plate is then removed and placed upon a second table, where it receives over its entire surface a thin layer of melted wax. When this wax has become sufficiently hardened, a knife is introduced beneath the portions of foil that remain, and these are gently lifted and removed with the wax immediately over them. What remains now is the original pattern traced in wax and resting on the glass. The plate thus prepared is then placed on the moving belts, or feeders, of the large machine and by them is conveyed under the falling sand-blast. Of course, this sheet of sand strikes with equal force on the whole surface; but where the wax layers intervene they act as shields, receiving the sand but checking its progress, while the exposed portions being glass, and therefore brittle, are roughened so as to present the appearance of a ground surface. After each plate passes through, it is again slightly heated, the wax removed, and the final appearance is such as indicated in Fig. 5. These illustrations, it may be stated, are from photographic imprints, taken from actual plates, and, as such, indicate with perfect exactness the character of the work. In these the light portions represent the ground or depolished surfaces, while the dark lines are those which, having been protected by the stencil shield of wax, were untouched.

FIG. 6.—MACHINE OPERATED BY EXHAUST INSTEAD OF BLAST.

When the surfaces to be acted upon are curved, as in the case of globes, tumblers, etc., a special device is needed. The feature of this is an exhaust-chamber, by the aid of which the sand is drawn up through a tube and projected upward, as shown in Fig. 6. Immedi-

ately above the orifice through which the sand rises, the stencil-covered globes are caused to revolve on spindles, and, when finished, have the appearance indicated in Fig. 7.

If the reader has been able to follow this necessarily brief description, he will readily perceive how, by the use of duplicate stencils, constructed of any tough substance, the work of engraving, once an art in itself, becomes merely a mechanical process. As the result of experiments, now nearly completed, a form of rubber ink has been devised which, when laid on paper, converts it into a stencil, sufficiently tough to resist the action of the blast. Then, again, it may be seen how designs, direct from Nature, may be transferred to glass or metal by merely attaching a leaf or vine to the surface, and exposing it to the action of the blast. Nor is glass the only substance that can be ground and engraved. All metals, when hardened, are as

FIG. 7.

readily cut. The zinc plates which are now being substituted for lithographic stone have their surfaces depolished by the sand-blast. As illustrative of the remarkable rapidity with which the sand-blast accomplishes its work, the following facts, regarding the cutting of inscriptions on the head-stones designed to mark the graves of soldiers buried in the national cemeteries, may be cited. The contractor having this work in charge at Rutland, Vermont, has three sand-blast machines, of the form indicated in Fig. 8.

In addition to the one man employed to tend these machines, he has a small force of boys, whose duty it is to attach and remove the

cast-iron letters which act as stencils. Thus equipped, the contractor is able to turn out three hundred head-stones a day, upon each of which is a handsomely-cut inscription averaging eighteen raised letters. It is estimated that, to accomplish a like result by the old process, a force of three hundred men would be needed. Another instance of the rapidity with which these little sand-engines do their work is shown in the engraving of glass globes, tumblers, etc., which can be done at the astounding rate of one a minute.

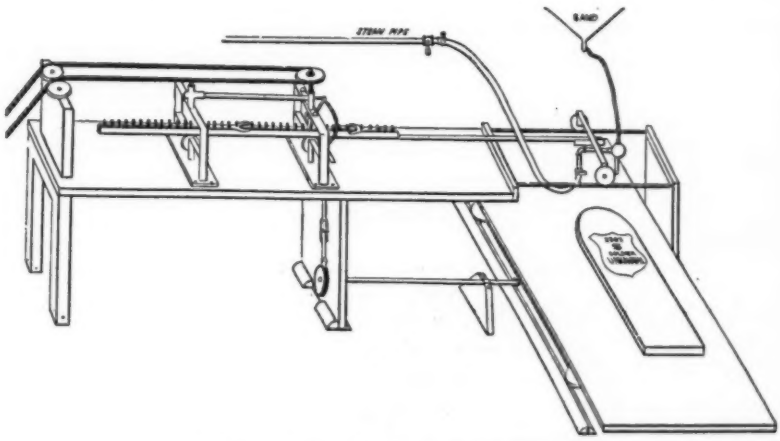


FIG. 8.—TILGHMAN'S SAND-BLAST STONE-MACHINE.

Extended space might be devoted to a mere recital of the actual present accomplishments of the sand-blast, and, were we to enter the field of speculation as to its possibilities, the range of its adaptation would tax the reader's credulity. We will therefore be content to refer to the following extract from the report of the judges at the fortieth exhibition of the American Institute, which, in awarding the inventor the great medal of honor, describes and commends his invention as follows:

"The process is designed to execute ornaments, inscriptions in *intaglio*, or relief, or complete perforations, in any kind of stone, glass, or other hard and brittle substance; or to cut deep grooves in natural rocks, in order to facilitate the process of quarrying; or to make circular incisions around the central mass of rock in the process of tunneling; or to remove slag, scale, and sand, from the surfaces of metal castings; or to clear the interior surfaces of boilers or boiler tubes of incrustations; or to cut ornaments or types from wood as well as from stone; or to depolish the surface of glass, producing by the aid of stencils or other partial protections, as the bichromatized gelatine of photographic negatives, every variety of beautiful figures, including copies of the finest lines, and the most delicate line engravings; or to prepare copper-plates in relief for printing, by making gelatine photographic pictures upon smooth surfaces of resin and pitch, cutting them out by the blast, and afterward moulding from them, and electrotyping the moulds.

"This process is without precedent. The use of sand in sawing marble, or in grinding glass by common methods, hardly furnishes an analogy."

Here follows a description of the device, concluding with the statement that "it is regarded by the judges as being one of the most remarkable and valuable inventions which the age has produced."

When it is announced that the judges who thus emphatically indorsed the claims of the sand-blast were Profs. Barnard, Mayer, and Morton, our readers will demand of the writer no apology for or qualification of his expressed opinion that the "Tilghman sand-blast is an invention which, in simplicity of construction and extent of application, has hardly an equal in the annals of American patents."

INSTINCT AND ACQUISITION.[1]

By D. A. SPALDING.

SO great was the influence of that school of psychology which maintained that we and all other animals had to acquire in the course of our individual lives all the knowledge and skill necessary for our preservation, that many of the very greatest authorities in science refused to believe in those instinctive performances of young animals about which the less learned multitude have never had any doubt. For example, Helmholtz, than whom there is not, perhaps, any higher scientific authority, says: "The young chicken very soon pecks at grains of corn, but it pecked while it was still in the shell, and when it hears the hen peck, it pecks again, at first seemingly at random. Then, when it has by chance hit upon a grain, it may, no doubt, learn to notice the field of vision which is at the moment presented to it."

At the meeting of this Association in 1872, I gave a pretty full account of the behavior of the chicken after its escape from the shell. The facts observed were conclusive against the individual-experience psychology. And they have, as far as I am aware, been received by scientific men without question. I would now add that not only does the chick not require to learn to peck at, to seize, and to swallow small specks of food, but that it is not a fact, as asserted, and generally supposed, that it pecks while still in the shell. The actual mode of self-delivery is just the reverse of pecking. Instead of striking forward and downward (a movement impossible on the part of a bird packed in a shell with its head under its wing), it breaks its way out by vigorously jerking its head upward, while it turns round within the shell, which is cut in two—chipped right round in a perfect circle some distance from the great end.

[1] Read at the Bristol meeting of the British Association.

Though the instincts of animals appear and disappear in such seasonable correspondence with their own wants and the wants of their offspring as to be a standing subject of wonder, they have by no means the fixed and unalterable character by which some would distinguish them from the higher faculties of the human race. They vary in the individuals as does their physical structure. Animals can learn what they did not know by instinct and forget the instinctive knowledge which they never learned, while their instincts will often accommodate themselves to considerable changes in the order of external events. Everybody knows it to be a common practice to hatch ducks'-eggs under the common hen, though in such cases the hen has to sit a week longer than on her own eggs. I tried an experiment to ascertain how far the time of sitting could be interfered with in the opposite direction. Two hens became broody on the same day, and I set them on dummies. On the third day I put two chicks a day old to one of the hens. She pecked at them once or twice; seemed rather fidgety, then took to them, called them to her and entered on all the cares of a mother. The other hen was similarly tried, but with a very different result. She pecked at the chickens viciously, and both that day and the next stubbornly refused to have any thing to do with them.

The pig is an animal that has its wits about it quite as soon after birth as the chicken. I therefore selected it as a subject of observation. The following are some of my observations: That vigorous young pigs get up and search for the teat at once, or within one minute after their entrance into the world. That if removed several feet from their mother, when aged only a few minutes, they soon find their way back to her, guided apparently by the grunting she makes in answer to their squeaking. In the case I observed the old sow rose in less than an hour and a half after pigging, and went out to eat; the pigs ran about, tried to eat various matters, followed their mother out, and sucked while she stood eating. One pig I put in a bag the moment it was born and kept it in the dark until it was seven hours old, when I placed it outside the sty, a distance of ten feet from where the sow lay concealed inside the house. The pig soon recognized the low grunting of its mother, went along outside the sty struggling to get under or over the lower bar. At the end of five minutes it succeeded in forcing itself through under the bar at one of the few places where that was possible. No sooner in than it went without a pause into the pig-house to its mother, and was at once like the others in its behavior. Two little pigs I blindfolded at their birth. One of them I placed with its mother at once: it soon found the teat and began to suck. Six hours later I placed the other a little distance from the sow; it reached her in half a minute, after going about rather vaguely; in half a minute more it found the teat. Next day I found that one of the two left with the mother, blindfolded, had got the blinders off; the

other was quite blind, walked about freely, knocking against things. In the afternoon I uncovered its eyes, and it went round and round as if it had had sight, and had suddenly lost it. In ten minutes it was scarcely distinguishable from one that had had sight all along. When placed on a chair it knew the height to require considering, went down on its knees and leaped down. When its eyes had been unveiled twenty minutes I placed it and another twenty feet from the sty. The two reached the mother in five minutes and at the same moment.

Different kinds of creatures, then, bring with them a good deal of cleverness, and a very useful acquaintance with the established order of Nature. At the same time all of them later in their lives do a great many things of which they are quite incapable at birth. That these are all matters of pure acquisition appears to me an unwarranted assumption. The human infant cannot masticate; it can move its limbs, but cannot walk, or direct its hands so as to grasp an object held up before it. The kitten just born cannot catch mice. The newly-hatched swallow or tomtit can neither walk, nor fly, nor feed itself. They are as helpless as the human infant. Is it as the result of painful learning that the child subsequently seizes an apple and eats it? that the cat lies in wait for the mouse? that the bird finds its proper food and wings its way through the air? We think not. With the development of the physical parts, comes, according to our view, the power to use them, in the ways that have preserved the race through past ages. This is in harmony with all we know. Not so the contrary view. So old is the feud between the cat and the dog, that the kitten knows its enemy even before it is able to see him, and when its fear can in no way serve it. One day last month, after fondling my dog, I put my hand into a basket containing four blind kittens, three days old. The smell my hand had carried with it set them puffing and spitting in a most comical fashion.

That the later developments to which I have referred are not acquisitions can be in some instances demonstrated. Birds do not *learn* to fly. Two years ago I shut up five unfledged swallows in a small box not much larger than the nest from which they were taken. The little box, which had a wire front, was hung on the wall near the nest, and the young swallows were fed by their parents through the wires. In this confinement, where they could not even extend their wings, they were kept until after they were fully fledged. Lord and Lady Amberley liberated the birds and communicated their observations to me, I being in another part of the country at the time. On going to set the prisoners free, one was found dead—they were all alive on the previous day. The remaining four were allowed to escape one at a time. Two of these were perceptibly wavering and unsteady in their flight. One of them, after a flight of about ninety yards, disappeared among some trees; the other, which flew more steadily, made a sweep-

ing circuit in the air, after the manner of its kind, and alighted, or attempted to alight, on a branchless stump of a beech; at last it was no more seen. No. 3 (which was seen on the wing for about half a minute) flew near the ground, first round the Wellingtonia, over to the other side of the kitchen-garden, past the bee-house, back to the lawn, round again, and into a beech-tree. No. 4 flew well near the ground, over a hedge twelve feet high to the kitchen-garden through an opening into the beeches, and was last seen close to the ground. The swallows never flew against any thing, nor was there, in their avoiding objects, any appreciable difference between them and the old birds. No. 3 swept round the Wellingtonia, and No. 4 rose over the hedge just as we see the old swallows doing every hour of the day. I have this summer verified these observations. Of two swallows I had similarly confined, one, on being set free, flew a yard or two too close to the ground, and rose in the direction of a beech-tree, which it gracefully avoided; it was seen for a considerable time sweeping round the beeches and performing magnificent evolutions in the air high above them. The other, which was observed to beat the air with its wings more than usual, was soon lost to sight behind some trees. Titmice, tomtits, and wrens, I have made the subjects of a similar experiment and with similar results.

Again, every boy who has brought up nestlings with the hand must have observed that, while for a time they but hold up their heads and open their mouths to be fed, they by-and-by begin quite spontaneously to snap at the food. Here the development may be observed as it proceeds. In the case of the swallow I am inclined to think that they catch insects in the air perfectly well immediately on leaving the nest.

With regard, now, to man, is there any reason to suppose that, unlike all other creatures, his mental constitution has to be in the case of each individual built up from the foundation out of the primitive elements of consciousness? Reason seems to me to be all the other way. The infant is helpless at birth for the same reason that the kitten or swallow is helpless—because of its physical immaturity; and I know of nothing to justify the contrary opinion, as held by some of our distinguished psychologists. Why believe that the sparrow can pick up crumbs by instinct, but that man must learn to interpret his visual sensations and to chew his food? Dr. Carpenter, in his "Mental Physiology," has attempted to answer this argument in the only way in which it could be answered. He has produced facts which appear to him to prove that "the acquirement of the power of visually guiding the muscular movements is experimental in the case of the human infant." More than forty years ago Dr. Carpenter took part in an operation performed on a boy three years old for congenital cataract. The operation was successful. In a few days both pupils were almost clear; but, though the boy "clearly recognized the *direc-*

tion of a candle or other bright object, he was as unable as an infant to apprehend its *distance;* so that, when told to lay hold of a watch, he groped at it just as a young child lying in its cradle." He gradually began to use his eyes; first in places with which he was not familiar, but it was several months before he trusted to them for guidance as other children of his age would do. No one will doubt the accuracy of any of these statements; but I cannot agree with Dr. Carpenter that he had in the case of the boy any thing "exactly parallel" to my experiment of hooding chickens at birth and giving them their sight at the end of one or two days. This boy was couched when three years old. Probably sight would have been at first rather puzzling to my chickens, had they not received it until they were six months old. Dr. Carpenter seems to have forgotten for the moment that instincts as well as acquisitions decay through desuetude, and that this is especially true when the faculties in question have never once been started into action and are of the kind which develop through exercise. Another and vital difference between Dr. Carpenter's experiments and mine is this, that, when at the end of two days I gave my chickens sight, I did not do so by poking out or lacerating the crystalline lenses of their eyes with a needle.

The presumption, then, that the progress of the infant is but the unfolding of inherited powers remains as strong as ever. With wings there comes to the bird the power to use them; and why should we believe that, because the human infant is born without teeth, it should, when they do make their appearance, have to discover their use by a series of happy accidents?

One word as to the origin of instincts. In common with other evolutionists, I have argued that instinct in the present generation may be regarded as the product of the accumulated experiences of past generations. More peculiar to myself, and giving special meaning to the word experience, is the view that the question of the origin of the most mysterious instinct is not more difficult than, or different from, but is the same with the problem of the origin of the physical structures of the creatures. For, however they may have come by their bodily organization, it, in my opinion, carries with it a corresponding mental nature.

In opposition to this view, it has been urged that we have only to consider almost any well-marked instinct to see that it could never have been a product of evolution. We, it is said most frequently, cannot conceive the experiences that might by inheritance have become the instincts; and we *can* see very clearly that many instincts are so essential to the preservation of the creatures that without them they could never have lived to acquire them. The answer is easy. Granting our utter inability to go back in imagination through the infinite multitude of forms, with their diversified mental characteristics, that stand between the greyhound and the speck of living jelly to which,

according to the theory of evolution, it is related by an unbroken line of descent—granting that we are, if possible, still less able to picture in imagination the process of change from any one form to another—what then? Not surely that the theory of evolution is false! For the same argument will prove that no man present can possibly be the son of his father. Our ignorance is very great, but it is not a very great argument.

The other objection, that the creatures could never have lived to acquire their more important instincts, rests on a careless misunderstanding of the theory of evolution. It assumes in the drollest possible way that evolutionists must believe that in the course of the evolution of the existing races there must have from time to time appeared whole generations of creatures that could not start on life from the want of instincts that they had not got. There can be no need to say more than that these unfortunate creatures are assumed to have been singularly unlike their parents. The answer is, that it is not the doctrine of evolution that the bodies are evolved first by one set of causes and the minds are put in afterward by another. This notion is but the still lingering shadow of the individual-experience psychology. As evolutionists, whether we take the more common view and regard the actions of animals as prompted by their feelings and guided by their thoughts, or believe, as I do, that animals and men are conscious automata, in either case we are under no necessity of assuming, in explanation of the origin of the most mysterious instincts, any thing beyond the operation of those laws that we see operating around us, but concerning which we have yet to learn more, perhaps, than we have learned.—*Nature.*

PRINCE RUPERT'S DROPS.

By WILLIAM LEIGHTON, Jr., S. B.

WHEN from fluidity glass is cooled to a solid structure in the ordinary temperature of the atmosphere, it is found to be very brittle or liable to fracture.

If the glass is so shaped as to be of unequal thickness in its different parts, it can seldom be cooled without fracture, and, if unbroken when cool, is liable to fracture with any subsequent change of temperature or by a sudden jar. Often this fracture takes place, in articles of considerable thickness, with an explosive force, perhaps breaking the glass into a thousand pieces. When glass breaks in this manner, it is said to "fly."

In order to prevent such liability to "fly," glass-ware is annealed.

The process of annealing glass consists in reducing its temperature more slowly than would occur in the air at ordinary temperatures.

An oven is so constructed that the heat of the glass is maintained by a current of heated air in which articles to be annealed are placed, and mechanism so contrived as very slowly to draw away the ware into currents of lower temperature. Or the ware is annealed in kilns, which are closed and sealed at a temperature a little less than that at which glass becomes plastic, and heated air being thus confined the kilns are many hours, often many days, in cooling. The more carefully and slowly glass is annealed, the less liable it is to "fly."

By cooling glass *more* rapidly than could occur in ordinary atmospheric temperatures, that is, by a process the reverse of annealing, Prince Rupert's drops are made.

The ordinary way to make these scientific curiosities is to drop a small quantity, usually less than half an ounce, of perfectly fluid glass into water. In falling, the glass will assume the form of a tear, with an elongated end extending into a thread.

Rupert drops are clear, bright, and hard, and may be struck with much violence upon the larger end without fracture, but if the thin, though tough and very elastic thread of the other extremity be broken off, the whole drop will explode into numberless fragments, much finer than the sand of which the glass was originally composed.

Why does this happen? and why must glass-ware be annealed in order to be serviceable? There is evidently such similarity of phenomena occurring in the drops and in unannealed glass that a satisfactory theory for the one ought to lead to the explanation of the other.

In an article on "Tempered Glass" contributed by Perry F. Nursey, C. E., to the *Popular Science Review*, and published in the September number of THE POPULAR SCIENCE MONTHLY, the following theory of the Prince Rupert's drops is given: "Glass and water, and—as far as present knowledge goes—no other substances besides, expand while passing from the fluid into the solid condition. The theory of the Rupert drops is, that the glass being cooled suddenly, by being dropped into cold water, expansion is checked by reason of a hard skin being formed on the outer surface. This exterior coating prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass were allowed to cool very gradually. An examination of the Rupert's drop shows the inner substance to be fissured and divided into a number of small particles. They exist in fact in a state of compression, with but little mutual cohesion, and are only held together by the external skin. So long as the skin remains intact, the tendency of the inner particles to expand and fill their proper space is checked and resisted by the superior compressive strain of the skin. Nor is the balance of the opposing forces disturbed by blows on the thick end of the drop, which vibrates as a whole, the vibrations not being transmitted from the exterior to the interior. But, by breaking off the tail of the drop, a vibratory movement is communicated along the crystalline surface,

admitting of internal expansion, by which the cohesion of the particles composing the external skin is overcome, and the glass is at once reduced to fragments."

In the "American Cyclopædia" (revised edition), under the word "annealing," are found the following enplanations: "When this" (glass) "is melted and shaped into articles which are allowed to cool in the air, the glass becomes too brittle for any use. The exterior cools first and forms a contracted crust, which shelters the interior particles; so that these continue longer in a semi-fluid state, and are prevented from expanding, as glass does in cooling, and uniting with the rest to form an homogeneous mass. The inner parts are thus constantly tending to expand. If, on the contrary, the glass is placed in a hot oven, and this is allowed to cool very slowly, the particles of glass appear to assume a condition of perfect equilibrium of cohesive force without tension, so that the mass becomes tough and elastic." And, again, in the same article: "Dr. Ure explains this phenomenon" (the explosive breaking of Prince Rupert's drops) "by referring it to the tendency of a crack once formed in the glass to extend its ramifications in different directions throughout the whole mass."

In the "Encyclopædia Britannica" (ninth edition), under the word "annealing," is found as follows concerning the phenomena of unannealed glass and Prince Rupert's drops: "The particles of the glass have a cohesive polarity which dictates a certain regularity in their arrangement, but which requires some time for its development. When the vessels are suddenly cooled, the surface-molecules only can have had time to dispose themselves duly, while those within are kept by this properly-formed skin in a highly-constrained situation; and it is only so long as the surface-film keeps sound that this constraint can be resisted. In the Rupert's drops it is plainly visible that the interior substance is cracked in every direction, and ready to fly to pieces."

The practical glass-maker, desirous of thoroughly understanding the true theory of annealing glass, that from such a comprehension he may endeavor to accomplish more perfection in his process, refers to the authorities quoted above, and finds himself bewildered by the theories and explanations here given. He notices that the foundation of the theory of the Rupert drop, and of the process of annealing, in the article of THE POPULAR SCIENCE MONTHLY, and in the "American Cyclopædia," is based upon the assertion that in passing from a fluid to a solid condition glass expands. Although well aware that certain substances, as water,[1] bismuth,[2] gray cast-iron,[3] and antimony,[4] expand while solidifying, yet he is constantly reminded, by phenomena occurring in the glass-house every moment under his eye, that the reverse of this takes place in the substance of glass.

[1] Ganot's "Physics," edition of 1873, p. 261.
[2] Miller's "Chemistry," vol. ii., p. 604.
[3] Bauerman's "Metallurgy of Iron," p. 233.
[4] Miller's "Chemistry," vol. ii., p. 595.

Upon the supposition that glass contracts in cooling, he bases the construction and working of his moulds, in which glass-ware is pressed, and the success of their operation assures him that he is working upon a safe conclusion.

For further assurance, he replaces an article of glass-ware, when cold, in the mould in which it was originally pressed, and finds that it easily returns to its place, and fails to fill the mould. With his calipers he measures carefully the glass and the mould, and finds the shrinkage has been about one-fiftieth of the original bulk.

He remembers that he has on his book-shelf a work [1] by Apsley Pellatt, in which that careful and accurate observer states as follows: "A piece of unannealed barometer-tube, forty inches long, measured when just drawn, will become about one-fourth of an inch shorter if annealed; whereas, if quickly cooled without annealing, it will only contract about one-eighth of an inch." It must be borne in mind that the barometer-tube, when just drawn, at the time when it is first measured, has already considerably cooled from a fluid state of the glass, and has effected a part of its shrinkage, although not yet solid or rigid in its structure.

As the gray cast-iron before mentioned is said to expand at the moment of solidifying, but afterward to contract with further cooling, he experiments with the view to ascertain if an analogous action takes place in glass. He tests the cooling of a crucible full of this molten material, to note if at any time in the cooling process an expansion of its substance takes place. Even from the first moment, when the crucible is taken from the extreme heat of the furnace, he finds that the surface of the vitreous mass takes a concave form, this concavity becoming more considerable as the cooling process goes on.

If there were expansion at the moment of solidifying, the mass would then bulge upward, that is, the concave line of the surface would be disturbed. But, as the concavity of this surface constantly and uninterruptedly increases until the mass becomes cold, he finds renewed proof of the shrinkage of solidifying glass.

His ordinary observation thus confirmed by careful tests and by other authority, he feels that there is no possibility for him to be in error in regard to this contraction of glass, which he sees constantly going on.

When he reads, in the article of THE POPULAR SCIENCE MONTHLY, that the exterior coating produced by the immediate chill of the surface of the glass "prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass were allowed to cool very gradually," he tries to remember an instance, where, in some very perfectly-annealed glass, there has been an indication of such fibrous nature, but finds himself unable, in his own experience, or in that of his

[1] "Curiosities of Glass-making," by Apsley Pellatt, London, 1849, p. 63.

workmen, to recall such structure in any case. He finds the substance of glass always presenting the same vitreous, amorphous appearance, except in cases of devitrification, and, in the absence of any proof of such condition, cannot bring himself to believe in glass of a fibrous structure.

He finds in "a cohesive polarity, which dictates to the particles of glass a certain regularity in their arrangement, but which requires some time for its development," as laid down in the "Brittanica," a theory which is far from satisfying or giving him any useful aid, and he requires some proof (which he cannot find) of such "polarity" before absolutely adopting this theory.

He looks in vain for the fissured character of the interior substance of the Rupert drop, mentioned in the article of THE POPULAR SCIENCE MONTHLY, and in the "Encyclopædia Britannica," but finding, even under the microscope, that the substance of the interior, as well as the exterior, of the drop is apparently solid and undisturbed, gives up his attempt to understand the authorities, and even Dr. Ure's explanation in the "American Cyclopædia," of the Rupert-drop phenomena, fails to satisfy him.

He now feels that, to pursue this subject further, he must put together the facts in his possession, and ascertain if their combination will not suggest a more satisfactory theory than those laid down in the books.

He begins, of course, upon the foundation which his twenty years' experience in the glass-house has strongly impressed on him, viz., the fact that in passing from a fluid to a solid state *glass shrinks.*

His next fact is that glass is a poor conductor of heat, as he has often noticed in the manipulation of heated glass, during its process of manufacture, that in the same piece of glass, and close together, are portions, the one solid and the other fluid.

To these facts he puts the third fact, that the surface of fluid or semi-fluid glass chills very quickly upon exposure to the air, and very quickly becomes solid.

Here are all the facts necessary by which to construct a theory for the explanation of the phenomena of fracture in unannealed glass and in the Rupert drops.

Watching a thick mass of glass cool, he notes the color: by an oblique look, he perceives that the surface has a green tint; while through this transparent tinted medium a direct look shows the centre still of a glowing red color. He knows by experience that the green tint in cooling crystal glass indicates solidification, while the red glow tells that such glass is yet soft. But, not depending upon his experience of color, he tests the surface with an iron tool and finds it absolutely rigid; then with a hammer breaks this rigid surface, and finds, as its color indicates, the centre still semi-fluid.

Here is proved the condition of an outer skin or shell of rigid

glass, and an interior substance, still soft, plastic, and constantly strained by a tendency to contract, to occupy smaller boundaries; but those boundaries cannot be moved without breaking. It is a struggle of forces. If the thickness of the glass be considerable, the constantly-increasing strain of contraction pulls so hard upon the shell, that the force of cohesion is unable to withstand it, and the shell, yielding with a shock, shivers the whole substance into fragments.

In the process of annealing, the heat of the oven keeps the surfaces of the glass articles from absolutely becoming rigid, so that they yield sufficiently to the strain of the contracting interior portions; and if the whole substance of each article cools exactly together, the exterior and interior all the time at the same temperature, there is no strain and the ware is perfectly annealed.

As it is practically impossible to accomplish a perfect equality of temperature, a perfect equilibrium of the molecules cannot be obtained; but so near an approach to it is accomplished in a well-constructed annealing oven, that the cohesion of the glass is easily able to withstand the trifling strain.

In this view the action of cooling glass is simple and easily understood, surely more simple than to imagine a tendency toward a fibrous constitution of substance, or the imperious "cohesive polarity" of the "Britannica" article.

Test this theory upon the Rupert-drop phenomenon, and its explanation will answer as well.

A small amount of fluid glass, when dropped into water, will immediately, by the action of its heat, envelop itself in a garment of steam, which protects its surface from contact with the water, until that surface is so cooled that such contact fails to crack it. To test this assumption, try the experiment with partially cooled or soft glass, and the result will be that *all* the drops will break in the water, on account of cracked surfaces. With fluid glass, many drops will be lost, not from the same cause, if the drops be not too large, but from excessive contraction; perhaps, out of a dozen only one or two will be saved.

The steam chills the surface of the glass much more rapidly than the air does, consequently the inner and fluid glass in the Rupert drop is inclosed in larger boundaries than if the drop had cooled in the air. Hence contractive force is very strongly exerted to draw in such excessive boundaries, but the curved form of the drop presents arches of strength to aid the power of cohesion and resist destruction.

One drop bursts in the water, another does the same, but perhaps the third is drawn forth entire, though curled and twisted, as if in the agony of its strain. Two of Nature's forces struggle fiercely for the mastery in this little drop, that gives no indication of the contest as it lies quietly before us. But break off the thread, and down goes the first of the little arches, that are holding up the surface against con-

traction. One arch, falling, brings down another, and, once started, they go in such rapid succession that the ear detects but one sound, one explosive burst, in which the imp of contraction exults in the ruin he has wrought.

The peculiarities of the Rupert drops are toughness, elasticity, and the property of breaking into small fragments when any fracture, however slight, is made; their strength to resist such fracture is, however, greater than that of annealed or unannealed glass.

When we consider that these same peculiarities are the characteristics of the so-called "toughened glass" of M. de la Bastie, and that the method of treating his "toughened" glass, in the cooling process, is at least analogous to that of the Rupert drops, we are forced to believe in a certain relationship between them.

The Rupert drop falls into a water-bath; M. de la Bastie's glass into an oleaginous bath, the exact composition of which has not been made public.

M. de la Bastie's glass is not malleable, is not unbreakable, but simply tougher, harder to break than the ordinary annealed glass; so also is the Rupert drop.

As the characteristic distinction between annealed glass and the Rupert drop is the excessive strain upon the molecules of the latter—contraction *versus* cohesion—it is fair to infer that the superior strength, toughness, and elasticity, of the Rupert drop are due to such strain. As it is harder to displace the key-stone of a loaded arch than of an unloaded one, the simile may hold good in this case, and the strain of contraction upon the molecules of the glass of a Rupert's drop may help resist any outside force tending to disturb cohesion. If an outside force could be so exerted as to act exactly in the same direction as the power of contraction acts, undoubtedly such force would be aided by contraction to destroy cohesion; but, acting in any other direction, contraction would aid cohesion to resist it. As the molecules of glass are exceedingly small, and as, in the cooling process, they one after another individually become rigid, the lines of their contractive strain become so complicated that it is very unlikely any outside force can be exerted in such direction as to unite its impulse with theirs against cohesion.

As the toughened glass of M. de la Bastie flies into many pieces when fracture is effected, in a manner analogous to the breaking of the Rupert drop, it is probable, at least, considering the process of the oil-bath, that such flying into fragments is due to a strain of contraction exerted by the molecules of its substance. And if such a strain exists, as the flying seems to prove, it is also reasonable to suppose that, exactly as in the case of the Rupert drop, this strain of contraction among the molecules of its mass produces the superior toughness, strength, and elasticity, which are claimed for this newly-invented glass.

THE OWNERSHIP OF THE DEAD.[1]

By SAMUEL B. RUGGLES, LL. D.

IN resorting to England for light on this subject, we encounter a body of law grown up under circumstances differing widely from our own. The jurisprudence of that country is peculiarly compounded, embracing largely the ecclesiastical element, from which ours is exempt; and it has given birth to anomalies which we are hardly required to adopt. This is strikingly manifest in the matter of the dead, in which the partition of juridical authority between the Church and the state, forming one composite system, has materially narrowed the powers and the action of the courts of common law. It is believed that an attentive examination of the history of this division of judicial power will show that it is wholly peculiar to England, and that the decisions and *dicta* of their courts and legal writers on this subject ought not to exert any controlling influence over our legal tribunals.

In surveying the various changes in the organization and powers of the British courts of justice, produced successively by the Roman, Saxon, and Norman conquests, it is difficult to fix with precision the period when the judicial authority began to be divided between the state and the Church. Christianity had made some progress in Britain while yet remaining under the Roman power, but does not appear to have mingled itself materially with the governmental administration. The Saxon conquerors, who succeeded the Roman in the fifth century, brought in paganism for about one hundred and fifty years; but it was extirpated about the close of the sixth century by the vigor of St. Augustin, under the pontificate of Gregory the Great. It is quite apparent that the clear-sighted incumbents of the Holy See by that time had perceived in the burial of the dead a very important and desirable element of spiritual dominion. It was the sagacity, not less than the piety, of that distinguished pontiff, which led him to introduce the custom of burial in churches, to the end, as he declared, that the relatives and friends of the dead might be induced more frequently to pray for their repose. Occasional interments in places of worship, or their immediate vicinity, had indeed been made by the early Christians, as far back as the reign of Constantine; but it was not until after the pontificate of Gregory, and the rapid increase by his successors of the temporal power of the Church, that burial-grounds were generally attached to places of worship, and subjected by formal consecration to ecclesiastical authority.

[1] Extract from a report on the "Law of Burial," made to the Supreme Court of the State of New York in 1856, by Hon. Samuel B. Ruggles, referee, in respect to compensation to owners of vaults in cemeteries, and to relatives of individuals buried in graves disturbed by legal proceedings. Reprinted in Providence, R. I., 1872. 46 pages.

The judicial history of the Romish Church in England, from the sixth century to the thirteenth, exhibits its earnest efforts and its steady and all but uninterrupted progress, not only in strengthening its proper spiritual power, but in obtaining the exclusive temporal, judicial cognizance of all matters touching the ecclesiastical edifices and their appendages, and especially their places of burial. During that period, the office of sepulture, originally only a secular duty, came to be regarded as a spiritual function—so much so, that the secular courts, in the cases as early as the 20th and 21st Edward I., cited in 2 Inst., 363, in determining whether or not a building was a church, inquired only whether it had sacraments *and sepulture.*

It is generally stated that burial in church-yards was introduced into England by Cuthbert, Archbishop of Canterbury, in the year 750. The form of their consecration is even yet preserved, in some of its essential features, by the Established Church. The invocation, as given by Burn, in his "Ecclesiastical Law," vol. i., p. 334, after declaring that the duty has been taught by God, "through his holy servants, in all ages, to assign places where the bodies of the saints may rest in peace and be preserved from all indignities," asks the divine acceptance "of the charitable work, in separating the portion of ground to that good purpose."

The sagacious policy of the Romish ecclesiastics, in attaching the place of interment to the church, was duly strengthened by the stringent provision of the canon law, which prohibited heretics from Christian burial. To repose in any but consecrated earth soon came to be ignominious; and thus the church-yard became a vital portion of the material machinery for enforcing spiritual obedience and theological conformity. Nor was the power neglected. It governed Europe for several hundred years, and it was but shortly before the Protestant Reformation in England that one Tracy, being publicly accused in convocation of having expressed heretical sentiments *in his will*, and being found guilty, a commission was issued to dig up his body, which was done accordingly.—(1 Burn, "Eccl. Law," p. 266.)

During the early portion of the Anglo-Saxon period, the power of the clergy over the dead was kept in check by uniting the lay with the clerical order in the ecclesiastical tribunals; but their jurisdictions were separated soon after the Norman conquest, and the effect upon the dead is plainly discernible. The exclusive power of the ecclesiastics, denominated in legal phrase "ecclesiastical cognizance," became not only executive, but judicial. It was executive, in taking the body into their actual, corporeal possession, and practically guarding its repose in their consecrated grounds; and it was judicial, as well in deciding all controversies involving the possession or the use of holy places, or the pecuniary emoluments which they yielded, as in a broader field, in adjudicating who should be allowed

to lie in consecrated earth, and, in fact, who should be allowed to be interred at all.

The deplorable superstition that could induce people to intrust such a power to any but its civil government and civil courts is amazing, and yet we find the sturdy English nation, under the government of William of Normandy, stripping their cherished Anglo-Saxon courts of all power to protect the dead, and yielding them up blindfold to priestly cognizance. As Sir William Blackstone well says, it was a "fatal encroachment" on the ancient liberties of England. Eight centuries have not sufficed to repair the mischief. Anselm and Becket, in modern garb, live even yet.

The deep-seated, fundamental idea of human burial lies in the mingling our remains with the mother earth. The "dust to dust! earth to earth! ashes to ashes!" of the Church—echoing, in deeper solemnity, the "*ter pulvere*" of Horace, and hallowing the dying wish of Cyrus—finds a universal response in the holiest instincts of man in every age. Here, then, was the tender spot for subtle power to touch. Logically pursuing this idea, the ecclesiastical process of excommunication prohibited burial in the earth at all, whether consecrated or not. The precise words of the *formula*, as used in the tenth century, gave over the body of the contumacious offender for food to the fowls of the air and beasts of the field: "Sint cadavera eorum, in escam volatilibus cœli, et bestiis terræ." In some instances the sentence was more definite and specific, confining the corpse to the hollow trunk of a tree, "in concavo trunco repositum." The essence of the idea being to keep the body out of the earth and on the surface, it was sometimes figuratively expressed, in monkish rhetoric, by "the burial of an ass," or by a stronger and more characteristic image, as "a dunghill:" "Sepultura *asini* sepeliantur, et in *sterquilinium* super faciem terræ sint." The afflicted but sinful laity, to hide the horror of the spectacle, were wont, at times, to cover the festering dead with a pile of stones, thereby rearing a *tumulus*, or "*bloc;*" so that the process came to be commonly known, in mediæval Latin, as "*imblocare corpus.*"—(Du Cange, Glossary, "Imblocare.")

The same dominant idea of the unfitness of spiritual offenders to pollute the earth can be distinctly traced through the judicial ecclesiastical condemnations for several centuries. John Huss and Jerome of Prague being at the stake for heresy, early in the fifteenth century, under the ecclesiastical order of the Council of Constance, their ashes were not allowed to mingle with the earth, but were cast into the Rhine.

The legal process of scattering the ashes of the heretic was evidently a very significant and cherished feature in the ecclesiastical code of procedure, and it was executed in the different portions of Christendom with all attainable uniformity and precision. Within its comprehensive range it embraced not only the ashes of the heretic

freshly burnt, but the mouldering remains of any who had been suffered, through mistake or inadvertency, to slip into their graves. Wycliffe, the first English translator of the Scriptures, had ventured, in life, to question certain points of dogmatic theology, but, dying in his bed, in the year 1384, had been allowed to sleep for forty-one years in a church-yard in Leicestershire. The assembled dignitaries in the Council of Constance, after duly disposing of the ashes of Huss and Jerome, judicially declared the heresy of Wycliffe, and his bones were accordingly dug up and burnt, and the ashes thrown into the river Avon, in the due exercise of the executive branch of ecclesiastical cognizance, in the year 1425 of the Christian era.

Nor was the ecclesiastical cognizance of the dead confined to delinquents of low degree, or in the plainer walks of life. The Emperor of Germany, Henry IV., the victor of more than sixty battles, dying under papal excommunication by Hildebrand, the seventh Gregory, was compelled to lie for five years unburied, in the very sight of the majestic cathedral of Spires, which his father had commenced, and he had completed.

But the high and transcendent energy of ecclesiastical cognizance was completely developed in England in the thirteenth century, when it reached its culminating point, with the whole kingdom as the defendant. From the year 1207 to the year 1213, the interdict of Innocent III. kept out of their lawful graves all the dead, from the Channel to the Tweed. No funeral-bell in the kingdom was permitted to toll; the corpses were thrown into ditches, without prayer or hallowed observance, and the last drop of priestly malice and vengeance was exhausted, in compelling all, who wished to marry, to solemnize the ceremony in the church-yard.

It was during this unbridled career of papal aggrandizement through these dark and dismal ages, that the ancient civil courts of England gradually lost their original legitimate authority over places of interment, as private property, and their proper and necessary control over the repose of the dead. The clergy monopolizing the judicial power over the subject, burial was committed solely to ecclesiastical cognizance, while the secular courts, stripped of all authority over the dead, were left to confine themselves to the protection of the monument, and other external emblems of grief, erected by the living. But these they guarded with singular solicitude. The tombstone, the armorial escutcheons, even the coat and pennons, and ensigns of honor, whether attached to the church edifice or elsewhere, were raised as "heirlooms" to the dignity of inheritable estates, and descended from heir to heir, who could hold even the parson liable for taking them down or defacing them.

The reverent regard of the common law for these memorials is curiously manifested by Coke in the "Third Institute," page 203, where he expatiates upon a monumental stone, in his time more than four

hundred years old, inscribed with the name of a Jewish rabbi, and inlaid in the ancient wall of London—as if to intimate that the law would protect from injury that venerable piece of antiquity.

But at this point the courts of the common law stopped, and held, in humble deference to the ecclesiastical tribunals, that the heir could maintain no civil action for indecently or even impiously disturbing the remains of his buried ancestor, declaring the only remedy to belong to the parson, who, having the freehold of the soil, could maintain trespass against such as should dig or disturb it. The line of legal demarkation established in this subject, between the ecclesiastical and the common-law courts, is thus defined by Coke: "If a nobleman, knight, esquire, etc., be buried in a church, and have his coat-armor and pennons, with his arms, and such other insigns of honor as belong to his degree or order, set up in the church, or *if a gravestone be laid or made for memory of him*, albeit the freehold of the church be in the parson, and that these be annexed to the freehold, yet cannot the parson, or any, take or deface them, but he is subject to an action to the *heire and his heires*, in the honor and memory of whose ancestor they were set up" (1st Inst., 4, 18 *b*). In the "Third Institute," page 203, he asserts the authority of the Church, as follows: "It is to be observed," says he, "that in every *sepulchre* that hath a monument, two things are to be considered, viz.: the monument, and the *sepulture* or buriall of the dead. The *buriall* of the *cadaver*, that is *caro data vermibus*" (flesh given to worms), "is *nullius in bonis*, and belongs to ecclesiastical cognizance; but as to the monument, action is given, as hath been said, at the common law for the defacing thereof."

With all proper respect for the legal learning of this celebrated judge, we may possibly question both the wisdom and the etymology of this verbal conceit, this fantastic and imaginary gift, or outstanding grant to the worms. In the English jurisprudence, a corpse was not given or granted to the worms, but it was taken and appropriated by the Church. In Latin, it was a "*cadaver*" only because it was some thing *fallen* (*á cadendo*), even as the remains of fallen cities, in the letter of Sulpicius to Cicero ("Lit. Fam.," 7), are denominated "*cadavera oppidorum.*"

The learned lexicographers and philologists Martinius and the elder Vossius, both of them contemporaries of Coke, wholly dissent from his whimsical derivation. Martinius derives "cadaver" from "*cadendo, quia stare non potest*," "Lexicon Philologicum Martinii," 1720; while Vossius unequivocally reproves the derivation in question, as an act of pleasant but inflated trifling. "*Suaviter nugantur*," says he, "qui cadaver *conflatum aiunt*, ex tribus vocibus, caro data vermibus" ("Etymologicon Linguæ Latinæ," Amsterdam, 1662). And yet this inflated Latin trifle, the offspring only of Coke's characteristic and inordinate love of epigram, has come down through the last three

hundred years, copied and recopied, and repeated again and again by judges and legal writers, until it has imparted its tincture to the laws of the dead, throughout every portion of the earth which listens to the English tongue.

But even the *dictum* itself, if closely examined, will not be found to assert that no individual can have any legal interest in a corpse. It does not at all assert that the corpse, but only that the "*buriall*" is "nullius in bonis;" and this assertion was legally true in England where it was made, for the peculiar reason above stated, that the temporal office of burial had been brought within the exclusive, legal cognizance of the Church, who could and would enforce all necessary rules for the proper sepulture and custody of the body, thus rendering any individual action in that respect unnecessary. The power thus exercised by the ecclesiastical tribunals was not spiritual in its nature, but merely temporal and juridical. It was a legal secular authority, which they had gradually abstracted from the ancient civil courts, to which it had originally belonged; and that authority, from the very necessity of the case, in the State of New York, must now be vested in its secular courts of justice.

The necessity for the exercise of such authority, not only over the burial, but over the corpse itself, by some competent legal tribunal, will appear at once if we consider the consequences of its abandonment. If no one has any legal interest in a corpse, no one can legally determine the place of its interment, nor exclusively retain its custody. A son will have no legal right to retain the remains of his father, nor a husband of his wife, one moment after death. A father cannot legally protect his daughter's remains from exposure or insult, however indecent or outrageous, nor demand their reburial, if dragged from the grave. The dead deprived of the legal guardianship, however partial, which the Church so long had thrown around them, and left unprotected by the civil courts, will become, in law, nothing but public nuisances, and their custody will belong only to the guardians of the public health, to remove and destroy the offending matter, with all practicable economy and dispatch. The criminal courts may punish the body-snatcher who invades the grave, but will be powerless to restore its contents. The honored remains of Alexander Hamilton, reposing in our oldest church-yard, wrapped in the very bosom of the community, built up to greatness by his consummate genius, will become "*nullius in bonis*," and belong to that community no longer. The sacred relics of Mount Vernon may be torn from their "mansion of rest," and exhibited for hire in our very midst, and no civil authority can remand them to the tomb.

Applied to the case now under examination, the doctrine will deny to a daughter, whose filial love had followed her father to the grave, and reared a monument to his memory, all right to ask that his remains, uprooted by the city authorities and cast into the street,

shall again be decently interred. In England, with judicial functions divided between the state and the Church, the secular tribunals would protect the monument, the winding-sheet, the grave-clothes, even down to the ribbon (now extant) which tied the *queue;* but the Church would guard the skull and bones. Which of these relics best deserves the legal protection of the Supreme Court of law and equity of the State of New York? Does not every dictate of common-sense and common decency demand a common protection, for the grave and all its contents and appendages? Is a tribunal like this under any legal necessity for measuring its judicial and remedial action by the narrow rule and fettered movement of the common law of England, crippled by ecclesiastical interference? May it not put forth its larger powers and nobler attributes, as a court of enlightened equity and reason?

The due protection of the dead engaged the earnest attention of the great lawgivers of the polished nations of antiquity. The laws of the Greeks carefully guarded the private rights of individuals in their places of interment; and a similar spirit shines forth, in the clear intelligence and high refinement of the Roman jurisprudence. In the "Digest of the Civil Law," pl. 47, title 12, we find the beneficent and salutary provision, which gave a civil remedy, by the "*Sepulchri violati actio*," to every one interested, for any wanton disturbance of a sepulchre, and where "Ulpian, prætor, ait; Cujus dolo malo sepulchrum violatum esse dicetur in eum in factum judicium dabo ut *ei ad quem pertineat*, quanti ob eam rem æquum, videbatur condamnetur. Si nemo erit ad quem pertineat, sive agere nolet; quicunque agere volet, ei centum aureorum, actionem dabo"—a sepulchre being comprehensively defined, by another clause, to be, any place in which the body or bones of a man were deposited: "*Sepulchrum est, ubi corpus ossave hominas, condita sunt.*"—("Dig.," pl. 7, § 2.)

Nor does the *dictum* of Coke, now under consideration, assert—for historically it would not be true—that no individual right to protect the repose of the dead had ever existed, under the common law of England. So far from that, we see in the provision above extracted from the "Digest," that the individual right did exist, during the greater part of the four hundred years when England, then called Britain, formed part of the Roman Empire. In the six centuries of Saxon rule which succeeded, as is forcibly observed by Chancellor Kent, "the Roman civilization, laws, usages, arts, and manners, must have left a deep impression, and have become intermixed and incorporated with Saxon laws and usages, and *constituted the body 'of the ancient English common law.'*"—(1 Kent's "Commentaries," p. 547.)

The provision in question had been introduced into the Roman jurisprudence, long before its systematic codification by Justinian. It bears on its face the name of Ulpian, the great Roman jurist, who

not only lived as early as the second century of the Christian era, but actually assisted (as Selden states in his "Appendix to Fleta") in the judicial administration of Britain. He was the contemporary, and doubtless the personal and professional friend, of the celebrated prætorian-prefect Papinian, himself the most distinguished lawyer of his age, and chief administrator, in the year 210, of the Roman government at York. Selden glowingly depicts the judicial illumination of that early British age, as flourishing alike under the "Jus Cæsareum," the imperial law, and its able administration by those two most accomplished and illustrious Romans, "viri peritissimi, illustrissimique è Romanis.—(Selden's "Appendix to Fleta," p. 478.)

Nor is there any reason to believe that the Romanized British, when released, in the fifth century, from their political allegiance to the empire, abandoned the civilization, or abrogated the laws or usages which they had so long enjoyed; still less that they would seek or desire, in any way, to withdraw from their sepulchres and graves the protection which those laws had so fully secured. There is not a shadow of historical evidence that, under the Saxon invaders, who succeeded the Roman governors, any less respect was shown for the buried dead. On the contrary, it is distinctly shown by the Scandinavian historians, that these partially civilized Saxons had been specially taught to reverence their places of burial by their great leader Odin, the father of Scandinavian letters, distinguished for his eloquence and persuasive power, and especially commemorated as being the first to introduce the custom of erecting gravestones in honor of the dead.

In the dim and flickering light by which we trace the laws of these long-buried ages, the fact is significant and instructive that, of the several founders of the seven little Saxon kingdoms constituting the Heptarchy, nearly all deduced their descent, more or less remotely, from Odin himself. Hengist, who led the Saxon forces into Britain, and became first King of Kent, claimed with peculiar pride to be his great-grandson—rendering it quite improbable that during the rule of himself or his race, or that of his kindred sovereigns, which lasted from three to four hundred years, Saxonized Britain learned to abandon its buried ancestors, or hold them, in law, "nullius in bonis."

Nor do we find, in the occasional inroads of the Danes temporarily disturbing the Saxon governments of England, any evidence that they obliterated, in the slightest degree, the reverential usages in the matter of the dead, coming down from Odin. The early laws of that rude people, carefully collected in the twelfth century by the learned antiquary Saxo Grammaticus, speak with abhorrence of those who insult the ashes of the dead, not only denouncing death upon the "alieni corruptor cineris," but condemning the body of the offender to lie forever unburied and unhonored.—("Law of Frotho," Saxo Grammaticus, lib. v.)

The law of the Franks, near neighbors of the Saxons, cited by Montesquieu ("Spirit of Laws," lib. 30, chap. 19), not only banished from society him who dug up a dead body for plunder, but prohibited any one from relieving his wants, until *the relatives of the deceased* consented to his readmission—thus legally and distinctly recognizing the peculiar and personal interest of the relatives in the remains.

We are, indeed, so surrounded by proof of the universal reverence of the Gothic nations for their buried ancestors that we are justified in assuming it to be historically certain that the barbarous idea of leaving the dead without legal protection never originated with them; that the enlightened provision of the Roman jurisprudence, which protected in Britain the individual right to their undisturbed repose, not only remained unaffected by the Saxon invasion, but was implanted by that event still more deeply in the ancient common law of England; and that it must have been vigorously enforced, as well by the earliest secular courts of the Anglo-Saxons, as in that transition period of their judicial history, when the sheriff and the bishop, sitting side by side on the bench, united the lay and the ecclesiastical authority in a single tribunal.

Nor was the right to protect the dead eradicated by the Norman conquest. It is true that the swarm of Romish ecclesiastics which poured into England with the Conqueror exerted themselves actively and indefatigably to monopolize for the Church the temporal authority over the dead; but that by no means proves that they were left unprotected. On the contrary, it was a concentration in the ecclesiastical body of every right which any individual had previously possessed, to secure their repose. The individual right was not extinguished, it was only absorbed by the Church, and held in suspense, until some political revolution or religious reformation should overthrow the ecclesiastical power which had thus secured its possession.

The ecclesiastical element was not eradicated from the framework of the English Government, either by the Reformation or the act of Parliament establishing the Protestant succession, but in the portion of the world which we inhabit the work has been more thoroughly accomplished. The English emigration to America—the most momentous event in political history—commenced in the very age when Chief-Justice Coke was proclaiming, as a legal dogma, the exclusive authority of the Church over the dead. The liberty-loving, God-fearing Englishmen who founded these American States had seen enough and felt enough of "ecclesiastical cognizance," and they crossed a broad and stormy ocean to a new and untrodden continent, to escape from it forever.

It may well be that some of the legislative enactments of these weather-beaten men, in the early morning of their political life, while yet unused to the meridian light of religious freedom, are disfigured by the same intolerance they had left behind them. They may have

even mingled in their general scheme of civil policy an ecclesiastical element sterner and more searching than that of the Church from which they dissented. The curious historian may analyze, if he will, the earnest puritanism of early New England, or even the sturdy bigotry of early New Netherland; it is enough for the Commonwealth of New York, "by the grace of God, free and independent," to know that its first written constitution, born in 1777, in the very depths of the Revolutionary struggle, extirpated from the body politic every lingering element of ecclesiastical cognizance or spiritual authority. On all its features it bears the unextinguishable love of religious freedom, brought to our shores by the refugees from ecclesiastical tyranny, not only in England, but in Holland and France. Its ever-memorable declaration of religious independence—offspring of the lofty intellect and noble heart of John Jay, and growing bright with his Huguenot blood—proclaims to the world the fundamental resolve, "not only to expel civil tyranny, but also to guard against that spiritual oppression and intolerance wherewith the bigotry and ambition of weak and wicked priests and princes have scourged mankind."

Following up this fixed determination, and yet with wise regard and unaffected reverence for the Christian Church in its purity, the illustrious authors of this Magna Charta of our religious liberty, prohibit any "minister of the gospel, or priest of any denomination," from holding any office, civil or military, within the State; inscribing in the organic law, thus unmistakably, their settled purpose to deliver both dead and living from ecclesiastical cognizance, to emancipate the courts of justice from every priestly and mediæval fetter, and to allow them to breathe, through all coming time, the invigorating air of ancient, Anglo-Saxon freedom.

It is a striking proof of the inveterate attachment, even of the most enlightened nations, to prescriptive authority, that the monkish idea of the church-yard as an engine of spiritual power not only lingers in England, but is boldly proclaimed in its very metropolis. Within the last two years, the Archdeacon of London, in an official address to the clergy of the Established Church within his district, openly complains of modern legislation in the British Parliament, in establishing extra-mural cemeteries around their crowded cities; for, says he, "the church and the *church-yard* of the parish have hitherto been one of the strongest ties, to *bind the people* at large to the communion of the Church." And again, "Burial *bound*, I say, *the people*, in the metropolis, to the Established Church."

It certainly is not for us to interfere with the ecclesiastical law of England, nor needlessly to criticise its claims to the respect of the people whom it binds. We only ask to banish its maxims, doctrines, and practices from our jurisprudence, and to prevent them from guiding, in any way, our judicial action. The fungous excrescence which required centuries for its growth may need an efflux of ages to re-

move. Burial in the British Islands may possibly remain, for many generations, subject exclusively to "ecclesiastical cognizance;" but in the new, transplanted England of the Western Continent the dead will find protection, if at all, in the secular tribunals, succeeding, by fair inheritance, to the primeval authority of the ancient, uncorrupted common law.

It is gratifying, however, to perceive that, even in the English courts, traces are becoming discernible of a disposition to recognize the ancient right of burial at common law. In the year 1820, a legal claim was made by one Gilbert to bury, in a London churchyard, the body of his wife in an iron coffin, but it was resisted by the churchwardens, Buzzard and Boyer, on the ground that it would injuriously prolong the period when the natural decay of the body and of a wooden inclosure would make room in the grave for another occupant. An application had been previously made in the same matter to the King's Bench, for a *mandamus* (reported in 2 Barn. and Ald., p. 806), on which occasion the distinguished counsel, Mr. Scarlett and Mr. Chitty, claimed that the right of interment existed at common law. In refusing the application, Chief-Justice Abbott said: "It may be admitted, for the purpose of the present question, that the right of sepulture is a *common-law right*, but I am of opinion that the *mode of burial* is a subject of ecclesiastical cognizance." Mr. Justice Holroyd, after duly reproducing Coke's *caro data vermibus*, declared that "burial is as much a matter of ecclesiastical cognizance as the prayers that are to be used, or the ceremonies that are to be performed at the funeral."

The matter, which had caused some public disturbance in London, was thereupon carried into the Ecclesiastical Court, then adorned by the learning and talents of Sir William Scott (since Lord Stowell). In the very elaborate and eloquent opinion delivered by the accomplished judge on that occasion (reported in 3 Phillimore, p. 335), he reviews the whole history of burial, from the remotest antiquity, philosophically tracing the progress of interment through the heathen and the Christian ages. Drawing a distinction between the coffined and uncoffined funerals of early times, he admits that many authoritative writers assert the right of a parishioner to be buried in his own parish church-yard, but he denies that it necessarily includes the right to bury a "trunk or chest" with the body. "*The right*," says he, "*strictly taken*, is, to be returned to the parent earth for dissolution, and to be carried there in a decent and inoffensive manner." The honest sense and feeling of the judge were evidently struggling with ecclesiastical law and usage, but he came to the conclusion that no mode of burial could be permitted which would prolong the natural decay of the body, or needlessly preserve its identity; that the lapse of a single generation is practically sufficient for mingling human remains with the earth, and destroying their identity; that, the dead

having no legal right to crowd the living, each buried generation must give way to its successor; and that, therefore, an iron coffin, which would unduly and unlawfully prolong the period for identifying the remains, was ecclesiastically inadmissible, unless an extra fee were paid to the Church.

The court will perceive, by the proofs in the case now under examination, that the remains of the exhumed body are identified beyond doubt or question. The skeleton of the "posthumous man" is now legally "standing in court," distinctly individualized; with his daughter, next and nearest of kin, at his side, to ask that the tribunal whose order for widening the street ejected him from the grave will also direct his decent interment.

It was the pride of Diogenes, and his disciples of the ancient school of cynics, to regard burial with contempt, and to hold it utterly unimportant whether their bodies should be burned by fire or devoured by beasts, birds, or worms; and a French philosopher of modern days, in a somewhat kindred spirit, descants upon the "glorious nothingness" of the grave, and that "nameless thing"—a dead body. The secular jurisprudence of France holds it in higher and better regard. In the interesting case reported in "Merlin's Répertoire," title "Sepulture," where a large tract of land near Marseilles had necessarily been taken for the burial of several thousand bodies, after the great plague of 1720, it was adjudicated, by the secular court, that the land should not be profaned by culture even of its surface, until the buried dead had mouldered into dust. The eloquent *plaidoyer* of the *avocat-général* upon that occasion dwells with emphasis on the veneration which all nations, in all ages, have shown for the grave—adding, however, with some little tinge of national irreverence, "C'est une *vénération toujours révocable!* et toujours subordonnée au bien public."

In portions of Europe, during the semi-barbarous state of society in the middle ages, the law permitted a creditor to seize the dead body of his debtor; and, in ancient Egypt, a son could borrow money by hypothecating his father's corpse; but no evidence appears to exist in modern jurisprudence of a legal right to convert a dead body to any purpose of pecuniary profit.

It will be seen that much of the apparent difficulty of this subject arises from a false and needless assumption in holding that nothing is property that has not a pecuniary value. The real question is not of the disposable, marketable value of a corpse, or its remains, as an article of traffic, but it is of the sacred and inherent right to its custody, in order decently to bury it and secure its undisturbed repose. The insolent dogma of the English ecclesiastical law, that a child has no such claim, no such exclusive power, no peculiar interest in the dead body of its parent, is so utterly inconsistent with every enlightened perception of personal right, so inexpressibly repulsive to every proper

moral sense, that its adoption would be an eternal disgrace to American jurisprudence. The establishment of a right so sacred and precious ought not to need any judicial precedent. Our courts of justice should place it, at once, where it should fundamentally rest forever, on the deepest and most unerring instincts of human nature, and hold it to be a self-evident right of humanity, entitled to legal protection, by every consideration of feeling, decency, and Christian duty. The world does not contain a tribunal that would punish a son who should resist, even unto death, any attempt to mutilate his father's corpse, or tear it from the grave for sale or dissection; but where would he find the legal right to resist, except in his peculiar and exclusive interest in the body?

The right to the repose of the grave necessarily implies the right to its exclusive possession. The doctrine of the legal right to open a grave in a cemetery, after a certain lapse of time, to receive another tenant, however it may be sanctioned by custom in the English church-yards, or by Continental usage at Père-la-Chaise and elsewhere, will hardly become acceptable to the American mind, still less the Italian practice of hastening the decomposition of the dead by corrosive elements. The right to the individuality of a grave, if it exist at all, evidently must continue, so long as the remains of the occupant can be identified—and the means of identifying can only be secured and preserved by separate burial. The due and decent preservation of human remains by separate burial is preëminently due to Christian civilization, which, bringing in the coffin and sarcophagus, superseded the heathen custom of burning, and "gave," in Lord Stowell's vivid phrase, "final extinction to the sepulchral bonfires."

THE RELATIONS OF WOMEN TO CRIME.

By ELY VAN DE WARKER, M. D.

II.

I SHALL, in this paper, consider briefly the sexual and other physical and mental conditions which modify woman's relations to crime. These conditions (*B*) mainly depend upon—1. Age; 2. Heredity; 3. Physical; and 4. Mental sexual peculiarities. In a former paper of this series,[1] I believe I proved, beyond a doubt, that there are types of mind which are purely the outcome of sex, and which define the mental condition of the sexes. In that paper, criminal statistics were used to assist in establishing the fact of sexual mental differences. Here the method is reversed, and sexual mental traits are employed to explain the known differences in the extent and degree of crime

[1] POPULAR SCIENCE MONTHLY, July, 1875.

existing among men and women. This will involve the use of some of the facts already considered. While it is true that the social conditions, which we have so briefly analyzed,[1] bear upon woman chiefly because she is as she is, yet they bear also upon the other sex. Many of the sexual conditions we shall study relate to women alone, and, therefore, in their criminal career, exist as a defining force. If, in the ordinary concerns of life, women exhibit mental traits which serve amply to distinguish them, and place limits to their activity, not less in the tabulated histories of crime are the same distinctions and limits found.

1. Age materially influences the extent and degree of crime in both sexes. In relation to physical and functional development, age exists as a defining force. It appears to affect the criminal careers of the sexes in two ways: by permitting such a degree of bodily power to be reached as to render possible criminal acts in different degrees; and, the bodily powers remaining the same, the varying mental conditions produce changes in the force and direction of the criminal impulse. Each period of life, therefore, is characterized by degrees and qualities of crime which belong to it. In other words, certain phases of crime are perpetrated at one period of life in excess of any other period. These remarks do not apply to both sexes equally, for these periods do not correspond either as to age, or in the nature of the offense, the excess of which distinguishes one period from another.

For the purpose of studying the influence of age upon the criminal career of women, I shall analyze the figures of Mr. F. G. P. Neison.[2] The materials embraced in the table of Mr. Neison are for five years, from 1834 to 1839; for, strange to say, the Home-Office returns, since the year last named, to the date of Mr. Neison's publication, ceased to give the age and sex with reference to classes of crime. In order to simplify the comparison, I shall take the number of male criminals corresponding in age to the female, as the standard of measurement in reference to any given division of crime. Fractions are omitted in reference to both sexes.

At twelve years of age and younger the proportion of females to males is 1 to 6 for crimes against persons, and for crimes against property without violence for the same age the proportion is again 1 to 6. Bearing in mind what has been said in a former chapter,[3] that the ratios of the sexes as to crimes against persons and property are 16 to to 100 for the former, and 26 to 100 for the latter, and which also correspond to the difference in strength between the sexes, we see that the element of sexual inequality in strength does not present itself as a factor. In other words, the correspondence in the proportion of the sexes to the two classes of crime represents physical equality, while

[1] Popular Science Monthly, November, 1875.

[2] "Contributions to Vital Statistics," table xxix., London, 1857.

[3] Popular Science Monthly, November, 1875.

the difference (1 to 6) is the result of mental sexual traits, which, even at this early age, present themselves. During the next four years the proportion in reference to crimes against persons is nearly double, being 1 to 11; while against property the proportion decreases, being 1 to 5. The average physical strength of the sexes for the second period (twelve to sixteen years) is about equal, so that this sudden proportional increase in crimes against persons in the male sex is the result almost entirely of those qualities which mentally characterize the male. This conclusion is rendered nearly positive by the fact that the maximum is attained by the males in the next five years, sixteen to twenty-one, and is only 1 to 12, during which period it is that the greatest difference in strength between the sexes is developed; yet this difference is represented by an increase of only 1 in the proportion. This agrees with what we know of men, that the development of the passions keeps just in advance of the development of the physical strength, just as the strength declines in advance of the passions. Studying for a moment longer this second period of life (twelve to sixteen) we learn this important fact: that in woman's criminal career it is, proportionally with man, the best period in her life, for at this time also occurs the greatest difference in crimes against property, 1 to 5, the maximal difference in the sexes, as to crimes against persons, being reached at twenty-one years. For the periods following of ten years each, the proportion steadily decreases in the following order, 1 to 9, 1 to 7, until at the decade, between forty and fifty years, we reach again the proportion of childhood (1 to 6). Now, the inference is, not t' t men grow better and women worse; but that the period of greatest passional intensity has been passed, while in both sexes the will has attained its greatest force. In other words, the period of caution has been reached. This accords with the law that the greatest mental vigor corresponds with structural completion. That this explanation is plausible is shown by the fact that the last decade mentioned is the period in which the proportion between the sexes in crimes against property is more nearly equal, being 1 to 2 and a fraction, and which for former decades steadily held at 1 to 3. There is a further confirmation of this, in the fact that for two periods, fifty to sixty, and sixty and upward, crimes against persons increase among men; the proportion being 1 to 9 and 1 to 10 respectively. That this is not the result of any increase of morality in the other sex, the uniform ratio of the sexes for crimes against property, during the ages last named, renders probable. From the same source we may obtain information which tends to show the truth of the remark made by M. Quetelet, that the proportion of women as to men increases "according to the necessity of the greater publicity before the crime can be perpetrated."[1] In the division of crime called, offenses against the currency, we have the conditions favorable to a more even proportion of the sexes. In an offense of this kind the

[1] *Loc. cit.*, p. 90.

physical equality is not involved. It becomes a question of secrecy, cunning, and shrewdness. These are mental qualities which exist with equal force in the sexes. Consequently in this division of crime for all ages we find a mean proportion of 1 to 2. Expressed in detail the proportion is equal in childhood, 1 to 2 at the next period, and 1 to 3 for the three following, until, at the decade between forty and fifty years, it drops to 1 to 2, and is equal again for the two following periods. The influences which cause equality in the proportions at the two extremes of ages are probably those which produce the same, or nearly the same, results in relation to the other orders of crime.

This analysis of Mr. Neison's statistics reveals to us a very interesting period in the lives of both sexes—that between forty and fifty years. For all the classes of crime examined, we find the sexes at this period proportionally approaching equality; being in two classes actually at that of childhood. These two classes of crime are those which involve the greatest violence, crimes against persons; and the least, crimes against the currency. For the first, I have already offered a reasonable explanation, that of the period of caution; but, in reference to the latter, we must search further, in order to get at a probable cause. In the last-named offense, we have as a characterizing mental trait the very condition which explains the decrease in the proportion for crimes against persons, and yet at the terminal periods of life we find it obeying the same law. There is one fact which forces itself upon the attention in connection with this; that the first approach to equality in the proportions of the sexes begins suddenly at the term of life between forty and fifty years. This period, for men especially, is that in which the forces engaged in structural repair and waste are in equilibrium. It is one of structural rest, but of functional activity. At no other period in the life of man, therefore, is he physically more competent to meet the demands of his mental life. With women, it is also a period of structural rest, linked to a state of functional completion, so far as the prime motive of sexual life is concerned. It appears reasonable, in view of this, that physical factors be excluded as a probable cause of the phenomenon. But there exist valid reasons for exempting the male sex partly from the operation of the laws affecting this equalization in the proportion of the sexes. These reasons show presumptively that the subtile and obscure laws of crime operate more actively upon the female than the male sex; that, in obedience to these laws, her relations to crime are prolonged into periods of life when men are becoming, to a certain extent, exempt from their operations.

My friend Mr. R. L. Dugdale, of New York, in his brilliant study of the natural history of crime,[1] by an analysis of Tables I. and II. of Mr. Neison,[2] arrives at important facts. In the tables referred to,

[1] "Thirtieth Annual Report of the Prison Association, State of New York," p. 179.

[2] *Loc. cit.*, pp. 303, 304.

crime is classified according to age, and percentages are calculated based upon the total population for each age specified. The maximum for male criminals is found in the period of twenty to twenty-five years, with a percentage to the total population of that age of .7702. Between fifty and sixty years the percentage drops to only .1694. The same law holds good for women, but with modified ratios. Comparing the two sexes, the following results are reached: the tendency to crime, as exhibited in its actual commission, for males at all ages until sixty, diminishes at the rate of 33.333 per centum. For females under similar conditions of age, it diminishes at the rate of 25 per centum. Keeping in view the liability to error in a search through the obscure underlying forces which seem to regulate human conduct in the aggregate, it nevertheless appears reasonable to expect an explanation of this phenomenon to lie in the physical rather than the mental conditions of the sexes at the terminal periods of life. In the decade which was above distinguished as that of physical equilibrium, the governing principles seemed to be the expression of mental forces; but, on reaching the sixtieth year of life, the conditions are reversed. While in the former the conditions of waste and repair were equal, in the latter the repair of the physical forces is exceeded by the waste. This is a law which applies equally to both sexes, but with this difference in the result: the occupation and the crimes which belong in such great excess to men are those which require more physical strength than the occupations and crimes which are adapted to the lesser strength of women. Let us take a familiar illustration: after a man at sixty years of age has retired from the scenes of his labor in the mine, or field, or workshop, the wife of the same age, or older, is yet profitably engaged in her lighter domestic duties. She is yet contributing as materially to the comforts of her family as during the more active years of the husband's life. Now, while it is quite evident that we must regard the cause of the sudden more near equality in the proportion of the sexes which presents itself in the period of life between forty and fifty years as due to psychical changes, the evidence is yet stronger that the ratio of the more rapid decrease of male criminals at the more advanced period of fifty to sixty years is due to the cause I have named—the rapid impairment of physical energy peculiar to the period. Since men greatly preponderate in those phases of crime which demand strength, belligerency, and publicity in the perpetration, the conclusion is legitimate that crime would rapidly decrease at the time of life in which these qualities are wanting, or are impaired. If we examine the relation of men to the orders of crime, in the perpetration of which these qualities are not necessary, and in which strength may be replaced by caution, and belligerency by cunning, as in offenses against the currency, and in the sixth division of Mr. Neison called "other offenses," embracing the lighter shades of criminal conduct, we shall see that the propor-

tions between the sexes characteristic of earlier ages hold on unchanged through this last period of life.

It will be interesting to return for a moment and examine what are the real proportions of the sexes, during the criminally most active period of life, between twenty-one and thirty years. While we would not expect in this period to find the groundwork laid for criminal conduct, yet it is the term of life, in both sexes, in which the effects of heredity, of early training, assume activity, and give shape and color to the destiny of the individual. What goes before may be called the germ period, and this the period of fruition. The years which precede the meridional term of life are under the influence of structural and intellectual genesis. It is the result of an aggregation of forces tending to a common end. Life has not reached the level of the conflicting emotions, passions, and activities, which at the completion of structure exist so potently. Activity at this period is the expression of simple laws, which lead to a uniform result. Mr. Neison, reasoning purely from statistics, arrives at the same conclusion, that "in the juvenile period of life the tendency to crime is under the influence of more constant laws or elements, and therefore shows less fluctuation than in mature life." [1] The same conclusions hold good at the closing years of life. Youth and old age unite in the degree and quality of crime. The aggregate of crime in general is committed at the earlier part of this intermediate period of both sexes. The crime of this decade of life is more than quadruple that of any other. During this period occur those differences in the tendency to crime between the sexes which affect the total results. During this period, sex powerfully asserts its influence. Sex is no longer existing potentially in incomplete structure; but it is partly the sum of completed structural effort. Psychically, it is emotion, passion, and unconscious cerebral activity. Physically, it is the difference in development and mechanical power. Each of these is a factor in the differences real and apparent in the tendency to crime existing between men and women. There are many other causes, some of the more important of which have already been referred to, and are of social rather than sexual origin. But social factors operate more strongly at this period than at any other. Society in all its phases is made up of the activities of this period of life. Those forces which in their totality express all there is of society, seem to concentrate and coincide with those forces which express all there is of sex, and tend to one period of life common to both men and women.

2. In this connection it is proper to examine the bearings of women to the hereditary tendency to crime. Recent study of the relations of sex to crime has shown that the hereditary element in the criminal tendency may assume sexual phases. This is exemplified by the law of movement in the direction of the least resistance. The he-

[1] *Loc. cit.*, p. 407.

reditary taint being a fixed factor, it assumes expression in acts which are most in accord with sexual peculiarities. This is nearly equivalent to Dr. Carpenter's theory of special mental aptitudes as giving direction to the force of habit;[1] except that its operation is extended to the hereditary transmissions of mental or physical qualities. It is only in the early middle period of life that, from the nature of things, we would expect to find the criminal tendency under the complete sway of sexual life. The inherited criminal tendency in childhood and early youth finds its outlet in a viciousness common to both sexes, or in the milder forms of crimes against property. This is asserted on general principles. Dr. Carpenter remarks that "this diversity may be in a great part attributed to changes in the physical constitution. Thus, the sexual feeling, which has a most powerful influence on the direction of the thoughts in adolescence, adult age, and middle life, has comparatively little effect at the earlier and later periods."[2] This also accords with Mr. Dugdale's theory of criminal analogues. This theory, in his important work,[3] is mainly brought out in relation to the entailment of crime, and its truth lies in the fact that, in the same family of criminals, while the males are thieves, the females are prostitutes—one the equivalent or analogue of the other. The same family, in the two extremes of life, childhood and old age, exhibits pauperism as either the reality or promise of a criminal career. From the fact that pauperism exists as a parasite upon productive society, and preys upon society to its permanent injury, and makes no return, it will be regarded in this paper as an equivalent to crime against property. When we consider that criminals by entailment are exposed to environments possessing essential qualities in common, it is reasonable to expect that in such crime would conform in a more regular manner to those laws which seem to govern moral conduct, than in those who drift into crime through impulse or misfortune. This, in a general sense, holds true. M. Prosper Despine, in his "Psychologie Naturelle," shows that incendiarism exists in the young of both sexes with the inherited taint, as a characteristic. M. Despine brings out with great force a mental condition of those who inherit crime that gives an additional cause for the operation of the laws of crime with almost undeviating regularity upon this class. This is the total or nearly total absence of the moral sense—moral idiocy—which isolates the offspring of criminal families from the children of untainted birth. By this moral blindness they are distinguished throughout their lives. Thus there are wanting in this class the moral elements which effect or impede the criminal tendency in others. The sense of right or wrong, the sense of shame or disgrace, in no way interferes with the criminal tendency. This is the very condition necessary for the unembarrassed operation of Mr. Dug-

[1] "Principles of Mental Physiology," p. 374.
[2] *Loc. cit.*, p. 365.
[3] "Thirtieth Report," etc., p. 146.

dale's very probable law of criminal analogues or equivalents. Hence we may say, with almost positive certainty, that the children of both sexes, with the inherited taint, are paupers; that adult life in the male is distinguished by pauperism and crime; that adult life in the female is devoted to prostitution, and that old age brings both sexes again to the state of pauperism. And here again we encounter the phenomenon revealed by an analysis of Mr. Neison's statistics: the criminal equivalent existing between childhood and senility. It is childhood and old age joining hands, as it were, over the fevered and crime-laden middle life. But, while the moral faculties are absent, the mental powers are perverted to an equal degree. Any one accustomed to closely observe confirmed criminals must be cognizant of the fact that they are not as other men in their habits of mind. What one observes may not be called insanity, in the full meaning of the word, but it appears to be a departure from the standard one forms from mingling with average men. I have noticed this especially with regard to women. From an experience of two years with criminal women undergoing punishment in the Onondaga Penitentiary, I cannot recall an instance in which mental traits were wanting to distinguish them from the average woman. In this class mental peculiarities may be intensified into actual insanity, and the tendency to it exist stronger than in any other class. M. Ribot[1] shows that hereditary crime and insanity are closely connected, and refers to Drs. Ferrus and Lélut, who have established the great frequency of insanity among criminals. Dr. Bruce Thompson, in a recent work,[2] supports this by figures, and proves that twelve per centum of insanity occurs among prisoners, with fifty per centum of recommittals, revealing the strength of the inherited tendency.

The two more important inherited criminal traits which reveal sexual types in their development are pauperism and prostitution. Pauperism appears to be as characteristic of the male sex as prostitution is of the female. The ratio of sexes receiving relief is twenty per cent. of men to thirteen per cent. of women, in out-door, and thirteen per cent. of men to 9.5 per cent. of women in almshouse relief. De Marsangy fixes the ratio at seven times more vagabondage among men than women.[3] As a rule, women receive relief—if single—while child-bearing, and if married they follow the condition of the husband; while widows drift back into prostitution. "Thus we find," remarks Mr. Dugdale, "that although the rates of wages are lower for women, charity is much more frequent among men."[4] The above relates to those who are known to receive relief. The hereditary strength of the last-named offense is shown by the Juke family, so

[1] "Heredity," p. 29.

[2] "The Hereditary Nature of Crime."

[3] "Étude sur la Moralité comparée de la Femme et de l'Homme," par M. Bonneville de Marsangy.

[4] *Loc. cit.*, p. 151.

carefully studied by Mr. Dugdale—52.4 per cent. of the women following prostitution. If hereditary disease accompanies the entailment of crime, pauperism is a matter of course; the subject rarely attaining the rank of a criminal, except in the most petty of the offenses against property. Pauperism is a condition of effeteness. It represents the dregs which drop downward through the several strata of society. Morally, it is the most negative condition of humanity. The pauper has sunk below the level of crime. He abstains from crime, not by moral restraints, but by inertness. The woman with the same taint has sunk below the level of the active phases of crime. She drifts into harlotry because it is easier than to steal. If disabled, she becomes a pauper, and thus oscillates between the almshouse and the brothel—a passionless, nerveless being, with all the normal energies crushed out under the burden of entailed defects.

3. It is a more difficult matter to trace through the complicated net-work of passions, emotions, and motives, which underlies the degrees and varieties of crime, the purely sexual physical factor. The main difficulty consists in discriminating this from the mental sexual differences which may exist as a cause of differentiation in crime. It is essential, if possible, to gain an approximate idea of the limits of these differences. With the present data at command, this can be accomplished only in the most superficial manner. There exists here more than the suspicion of a great law, the operation of which, if fully known, would clear up many of the doubts lingering around this important subject. While the physical differences will serve to explain the varying relations of the sexes to crime in their broader and more superficial aspects, the mental sexual traits will serve to define the differences in motives, tendencies, and innate moral proclivities of the sexes. Instead of being satisfied with the simple explanation, that the extent of man's excess over woman as a criminal represents the excess of woman over man as a moral being, this knowledge would show that this is not a question of comparative morality alone, but one of intellectual equivalents. To study carefully the scope of the moral equivalents of the sexes is to reach the relations of things in their genesis. It is in this way that the relations of the sexes socially, as well as in crime, will be taken out of the realm of sentimentalism and placed upon a basis of fact. Sentimental views of the relationship of women to crime exist so generally, that they act as a force in the way of an unbiased investigation of the subject. Take, for instance, such a writer as M. de Marsangy,[1] whose motive is the serious one of the amelioration of the penal laws in their bearings upon women, who gravely concludes that man has a "nature less noble, less delicate, less perfect than woman," and yet quotes approvingly that, "*Das Weib ist Engel oder Teufel.*" It is this personal bias which has hitherto obscured this subject, and rendered the work of such writers

[1] *Loc. cit.*, p. 133.

as M. de Marsangy useless for scientific purposes. Fortunately, this style of scientific writing belongs to the French school of both sentiment and morals.

The mental reflex result of physical strength, as expressed in the criminal act, is more clearly shown in crimes against property attended with violence. Distinguishing it from the other orders of crime—malicious offenses against property, and offenses without violence—we have the motive in the first-mentioned class narrowed to the desire of possession, but so associated with the consciousness of personal strength that it is employed as an agent of the crime. Belligerency, revenge, and other emotions which tend to crime, are absorbed in the order of malicious offenses, and thus the field is left clear, in the class under analysis, for the full play of the physical factor. Omitting ages under sixteen years, as being too nearly equal physically in the sexes, and basing our proportion on the number of criminals of both sexes from that age to twenty-one years, the proportion is 1 woman to 18 men, while for the ten years following it is 1 to 20.[1] This is twice the proportion between the sexes for crimes against persons, and seven times that for crimes against property without violence, for corresponding ages. When we contrast this with the fact that the mean proportion between the sexes for all crimes against property is 1 to 4, and for crimes against the person it is 1 to 6, we may form an idea of the enormous influence of physical strength as a restraint to woman's criminal tendencies. We have, however, to modify this somewhat, by giving more or less value to woman's tendency to avoid those crimes which require publicity in both the planning and perpetration, and which is implied in violent crimes against property; but even giving this trait due weight, the physical factor as exhibited in this order of crime is the one which, more than any other, defines its character. While woman's deficient physical strength, compared to man's, acts so powerfully as an obstacle in the division of crime just considered, it is highly probable that in other offenses it also acts in the same manner, varying in amount, as this quality is necessary to the successful perpetration of the crime. In those crimes in which this factor does not enter, we at once notice that the ratios of the sexes approximate. In adultery, for instance, the proportion of the sexes is about the same.[2] In infanticide, I have already remarked on the ease with which women enter upon a criminal course, when this conforms to the direction of purely sexual qualities; and, undoubtedly, intensity is added by the absence of physical strength as a requisite to the perpetration of the crime. In crimes against the currency, the same near equality in the number of the sexes involved may be noticed, and the fact that the proportions for the most active period of adult life and for childhood and old age are about the same renders it highly probable that this

[1] Nelson, *loc. cit.*

[2] De Marsangy, *loc. cit.*

equality is accounted for by the physical strength required for its perpetration being possessed equally by the sexes. In crimes against persons, the influence of this factor can be traced, but not in so marked a manner as in the crimes referred to. In poisoning, for instance, the ratio between the sexes is 91 women to 100 men,[1] and while active mental traits may in part exist as causes for this nearly equal ratio of the sexes, yet the total absence of any need of physical strength must be given due value. Poison is essentially a weapon of weakness. It figures largely in history as the agent of women and politicians. One reason, which probably existed in mediæval days, but which cannot be regarded in modern times, was the difficulty of detection in cases of death by poisoning. It was surrounded by an atmosphere of horrible suspicion, which was never relieved by certainty. It was selected as a political agent by reason of this secrecy, by both sexes, and thus at this period had no sexual qualities. Modern advances in chemistry have rendered poisoning one of the most surely detected of all crimes, and its perpetration has become a characteristic of the weak and cowardly. In some other offenses, as in incendiarism, in which physical strength is as unessential as in poisoning, the ratio between the sexes falls to 34 in 100. Although this is a crime well within the compass of woman's physical abilities, yet it involves other elements, which deter women from its perpetration. Motive, which is the exciting cause of crime and enters largely into the intensity of the tendency, cannot act so powerfully in the latter as the former crime. In order to kill, a stronger motive is required than to burn. Incendiarism requires considerable personal exposure, and danger of immediate detection. Parricide with a ratio of 50 to 100, and wounding of parents with a ratio of 22 to 100 (Quetelet), offer a remarkable contrast to murder and the wounding of strangers, with a ratio taken together of 9 to 100. The necessity of physical strength exists equally in the perpetration of these crimes. The marked difference in ratio, therefore, must be explained by other means. Opportunity and domesticity, already referred to in a former paper, exist largely as the cause of the difference. M. Quetelet, speaking in general terms of the influence of opportunity and domestic habits upon woman's criminal career, remarks: "They can only conceive and execute guilty projects on individuals with whom they are in the greatest intimacy; thus, compared with man, her assassinations are more often in her family than out of it." It would be difficult to present a stronger argument of the influence of woman's social position as a restraint to crime. As we observe in the crimes just referred to, it is not the enormity of the offense which restrains, for we have in parricide twelve times the frequency of murder; it is not weakness, for then parricide, murder, and wounding, should agree in frequency. We are able to trace in this no influence of morality, it is simply the result of the varying degrees of opportunity, domestic life, and mental peculiarities.

[1] Quetelet, *loc. cit.*, p. 91.

THE HISTORY OF TWINS, AS A CRITERION OF THE RELATIVE POWERS OF NATURE AND NURTURE.[1]

By FRANCIS GALTON, F.R.S

THE exceedingly close resemblance attributed to twins has been the subject of many novels and plays, and most persons have felt a desire to know upon what basis of truth those works of fiction may rest. But twins have many other claims to attention, one of which will be discussed in the present memoir. It is, that their history affords means of distinguishing between the effects of tendencies received at birth and of those that were imposed by the circumstances of their after-lives; in other words, between the effects of nature and of nurture. This is a subject of especial importance in its bearings on investigations into mental heredity, and I, for my part, have keenly felt the difficulty of drawing the necessary distinction whenever I tried to estimate the degree in which mental ability was, on the average, inherited. The objection to statistical evidence in proof of its inheritance has always been: "The persons whom you compare may have lived under similar social conditions and have had similar advantages of education, but such prominent conditions are only a small part of those that determine the future of each man's life. It is to trifling accidental circumstances that the bent of his disposition and his success are mainly due, and these you leave wholly out of account—in fact, they do not admit of being tabulated, and therefore your statistics, however plausible at first sight, are really of very little use." No method of inquiry which I have been able to carry out—and I have tried many methods—is wholly free from this objection. I have therefore attacked the problem from the opposite side, seeking for some new method by which it would be possible to weigh in just scales the respective effects of nature and nurture, and to ascertain their several shares in framing the disposition and intellectual ability of men. The life-history of twins supplies what I wanted. We might begin by inquiring about twins who were closely alike in boyhood and youth, and who were educated together for many years, and learn whether they subsequently grew unlike, and, if so, what the main causes were which, in the opinion of the family, produced the dissimilarity. In this way we may obtain much direct evidence of the kind we want; but we can also obtain yet more valuable evidence by a converse method. We can inquire into the history of twins who were exceedingly unlike in childhood, and learn how far they became assimilated under the

[1] In my "English Men of Science," 1874, p. 12, I treated this subject in a cursory way. It subsequently occurred to me that it deserved a more elaborate inquiry, which I made, and of which this paper is a result.

influence of their identical nurtures; having the same home, the same teachers, the same associates, and in every other respect the same surroundings.

My materials were obtained by sending circulars of inquiry to persons who were either twins themselves or the near relations of twins. The printed questions were in thirteen groups; the last of them asked for the addresses of other twins known to the recipient who might be likely to respond if I wrote to them. This happily led to a continually-widening circle of correspondence, which I pursued until enough material was accumulated for a general reconnaissance of the subject.

There is a large literature relating to twins in their purely surgical and physiological aspect. The reader interested in this should consult "Die Lehre von den Zwillingen," von L. Kleinwächter, Prague, 1871; it is full of references, but it is also disfigured by a number of numerical misprints, especially in page 26. I have not found any book that treats of twins from my present point of view.

The reader will easily understand that the word "twins" is a vague expression, which covers two very dissimilar events; the one corresponding to the progeny of animals that have usually more than one young one at a birth, and the other corresponding to those double-yolked eggs that are due to two germinal spots in a single ovum. The consequence of this is, that I find a curious discontinuity in my results. One would have expected that twins would commonly be found to possess a certain average likeness to one another; that a few would greatly exceed that degree of likeness, and a few would greatly fall short of it; but this is not at all the case. Twins may be divided into three groups, so distinct that there are not many intermediate instances; namely, strongly alike, moderately alike, and extremely dissimilar. When the twins are a boy and a girl, they are never closely alike; in fact, their origin never corresponds to that of the above-mentioned double-yolked eggs.

I have received about eighty returns of cases of close similarity, thirty-five of which entered into many instructive details. In a few of these not a single point of difference could be specified. In the remainder, the color of the hair and eyes was almost always identical; the height, weight, and strength were generally very nearly so, but I have a few cases of a notable difference in these, notwithstanding the resemblance was otherwise very near. The manner and address of the thirty-five pairs of twins are usually described as being very similar, though there often exists a difference of expression familiar to near relatives but unperceived by strangers. The intonation of the voice when speaking is commonly the same, but it frequently happens that the twins sing in different keys. Most singularly, that one point in which similarity is rare is the handwriting. I cannot account for this, considering how strongly handwriting runs in families, but I am

sure of the fact. I have only one case in which nobody, not even the twins themselves, could distinguish their own notes of lectures, etc.; barely two or three in which the handwriting was undistinguishable by others, and only a few in which it was described as closely alike. On the other hand, I have many in which it is stated to be unlike, and some in which it is alluded to as the only point of difference.

One of my inquiries was for anecdotes as regards the mistakes made by near relatives, between the twins. They are numerous, but not very varied in character. When the twins are children, they have commonly to be distinguished by ribbons tied round their wrist or neck; nevertheless, the one is sometimes fed, physicked, and whipped by mistake for the other, and the description of these little domestic catastrophes is usually given to me by the mother, in a phraseology that is somewhat touching by reason of its seriousness. I have one case in which a doubt remains whether the children were not changed in their bath, and the presumed A is not really B, and *vice versa*. In another case an artist was engaged on the portraits of twins who were between three and four years of age; he had to lay aside his work for three weeks, and, on resuming it, could not tell to which child the respective likenesses he had in hand belonged. The mistakes are less numerous on the part of the mother during the boyhood and girlhood of the twins, but almost as frequent on the part of strangers. I have many instances of tutors being unable to distinguish their twin pupils. Thus, two girls used regularly to impose on their music-teacher when one of them wanted a whole holiday; they had their lessons at separate hours, and the one girl sacrificed herself to receive two lessons on the same day, while the other one enjoyed herself. Here is a brief and comprehensive account: "Exactly alike in all, their school-masters never could tell them apart; at dancing-parties they constantly changed partners without discovery; their close resemblance is scarcely diminished by age." The following is a typical school-boy anecdote: Two twins were fond of playing tricks, and complaints were frequently made; but the boys would never own which was the guilty one, and the complainants were never certain which of the two he was. One head-master used to say he would never flog the innocent for the guilty, and another used to flog both.

No less than nine anecdotes have reached me of a twin seeing his or her reflection in a looking-glass, and addressing it, in the belief that it was the other twin in person. I have many anecdotes of mistakes when the twins were nearly grown up. Thus: "Amusing scenes occurred at college when one twin came to visit the other; the porter on one occasion refusing to let the visitor out of the college-gates, for, though they stood side by side, he professed ignorance as to which he ought to allow to depart."

Children are usually quick in distinguishing between their parent and his or her twin; but I have two cases to the contrary. Thus, the

daughter of a twin says: "Such was the marvelous similarity of their features, voices, manner, etc., that I remember, as a child, being very much puzzled, and I think, had my aunt lived much with us, I should have ended by thinking I had two mothers." The other, a father of twins, remarks: "We were extremely alike, and are so at this moment, so much so that our children up to five and six years old did not know us apart."

I have four or five instances of doubt during an engagement of marriage. Thus: "A married first, but both twins met the lady together for the first time, and fell in love with her there and then. A managed to see her home and to gain her affection, though B went sometimes courting in his place, and neither the lady nor her parents could tell which was which." I have also a German letter, written in quaint terms, about twin brothers who married sisters, but could not easily be distinguished by them.[1] In the well-known novel by Mr. Wilkie Collins of "Poor Miss Finch," the blind girl distinguishes the twin she loves by the touch of his hand, which gives her a thrill that the touch of the other brother does not. Philosophers have not, I believe, as yet investigated the conditions of such thrills; but I have a case in which Miss Finch's test would have failed. Two persons, both friends of a certain twin lady, told me that she had frequently remarked to them that "kissing her twin sister was not like kissing her other sisters, but like kissing herself—her own hand, for example."

It would be an interesting experiment, for twins who were closely alike, to try how far dogs could distinguish between them by scent.

I have a few anecdotes of strange mistakes made between twins in adult life. Thus an officer writes: "On one occasion when I returned from foreign service, my father turned to me and said, 'I thought you were in London,' thinking I was my brother—yet he had not seen me for nearly four years—our resemblance was so great."

The next and last anecdote I shall give is, perhaps, the most remarkable of those that I have; it was sent me by the brother of the twins, who were in middle life at the time of its occurrence: "A was again coming home from India, on leave; the ship did not arrive for some days after it was due; the twin brother B had come up from his quarters to receive A, and their old mother was very nervous. One morning A rushed in, saying, 'O mother, how are you?' Her answer was, 'No, B, it's a bad joke; you know how anxious I am!' and it was a little time before A could persuade her that he was the real man."

Enough has been said to prove that an extremely close personal

[1] I take this opportunity of withdrawing an anecdote, happily of no great importance, published in "Men of Science," p. 14, about a man personating his twin brother for a joke at supper, and not being discovered by his wife. It was told me on good authority; but I have reason to doubt the fact, as the story is not known to the son of one of the twins. However, the twins in question were extraordinarily alike, and I have many anecdotes about them sent me by the latter gentleman.

resemblance frequently exists between twins of the same sex; and that, although the resemblance usually diminishes as they grow into manhood and womanhood, some cases occur in which the resemblance is lessened in a hardly perceptible degree. It must be borne in mind that the divergence of development, when it occurs, need not be ascribed to the effect of different nurtures, but that it is quite possible that it may be due to the appearance of qualities inherited at birth, though dormant, like gout, in early life. To this I shall recur.

There is a curious feature in the character of the resemblance between twins, which has been alluded to by a few correspondents; it is well illustrated by the following quotations. A mother of twins says: "There seemed to be a sort of interchangeable likeness in expression, that often gave to each the effect of being more like his brother than himself." Again, two twin brothers, writing to me, after analyzing their points of resemblance, which are close and numerous, and pointing out certain shades of difference, add: "These seemed to have marked us through life, though for a while, when we were first separated, the one to go to business, and the other to college, our respective characters were inverted; we both think that at that time we each ran into the character of the other. The proof of this consists in our own recollections, in our correspondence by letter, and in the views which we then took of matters in which we were interested." In explanation of this apparent interchangeableness, we must recollect that no character is simple, and that in twins who strongly resemble each other, every expression in the one may be matched by a corresponding expression in the other, but it does not follow that the same expression should be the dominant one in both cases. Now, it is by their dominant expressions that we should distinguish between the twins; consequently, when one twin has temporarily the expression which is the dominant one in his brother, he is apt to be mistaken for him. There are also cases where the development of the two twins is not strictly *pari passu;* they reach the same goal at the same time, but not by identical stages. Thus: A is born the larger, then B overtakes and surpasses A, and is in his turn overtaken by A, the end being that the twins become closely alike. This process would aid in giving an interchangeable likeness at certain periods of their growth, and is undoubtedly due to nature more frequently than to nurture.

Among my thirty-five detailed cases of close similarity, there are no less than seven in which both twins suffered from some special ailment or had some exceptional peculiarity. One twin writes that she and her sister "have both the defect of not being able to come downstairs quickly, which, however, was not born with them, but came on at the age of twenty." Another pair of twins have a slight congenital flexure of one of the joints of the little finger; it was inherited from a grandmother, but neither parents, nor brothers, nor sisters, show the

least trace of it. In another case, one was born ruptured, and the other became so at six months old. Two twins at the age of twenty-three were attacked by toothache, and the same tooth had to be extracted in each case. There are curious and close correspondences mentioned in the falling off of the hair. Two cases are mentioned of death from the same disease; one of which is very affecting. The outline of the story was, that the twins were closely alike and singularly attached, and had identical tastes; they both obtained government clerkships, and kept house together, when one sickened and died of Bright's disease, and the other also sickened of the same disease and died seven months later.

In no less than nine out of the thirty-five cases does it appear that both twins are apt to sicken at the same time. This implies so intimate a constitutional resemblance, that it is proper to give some quotations in evidence. Thus, the father of two twins says: "Their general health is closely alike; whenever one of them has an illness, the other invariably has the same within a day or two, and they usually recover in the same order. Such has been the case with whooping-cough, chicken-pox, and measles; also with slight bilious attacks, which they have successively. Latterly, they have had a feverish attack at the same time." Another parent of twins says: "If any thing ails one of them, identical symptoms *nearly always* appear in the other; this has been singularly visible in two instances during the last two months. Thus, when in London, one fell ill with a violent attack of dysentery, and within twenty-four hours the other had precisely the same symptoms." A medical man writes of twins with whom he is well acquainted: "While I knew them, for a period of two years, there was not the slightest tendency toward a difference in body or mind; external influences seemed powerless to produce any dissimilarity." The mother of two other twins, after describing how they were ill simultaneously up to the age of fifteen, adds that they shed their first milk-teeth within a few hours of each other.

Trousseau has a very remarkable case (in the chapter on asthma) in his important work "Clinique Médicale." (In the edition of 1873, it is in vol. ii., p. 473.) It was quoted at length in the original French, in Mr. Darwin's "Variation under Domestication," vol. ii., p. 252. The following is a translation:

"I attended twin brothers so extraordinarily alike, that it was impossible for me to tell which was which without seeing them side by side. But their physical likeness extended still deeper, for they had, so to speak, a yet more remarkable pathological resemblance. Thus, one of them, whom I saw at the Néothermes at Paris, suffering from rheumatic ophthalmia, said to me, 'At this instant my brother must be having an ophthalmia like mine;' and, as I had exclaimed against such an assertion, he showed me a few days afterward a letter just received by him from his brother, who was at that time at Vienna,

and who expressed himself in these words: 'I have my ophthalmia; you must be having yours.' However singular this story may appear, the fact is none the less exact; it has not been told to me by others, but I have seen it myself; and I have seen other analogous cases in my practice. These twins were also asthmatic, and asthmatic to a frightful degree. Though born in Marseilles, they were never able to stay in that town, where their business affairs required them to go, without having an attack. Still more strange, it was sufficient for them to get away only as far as Toulon in order to be cured of the attack caught at Marseilles. They traveled continually, and in all countries, on business affairs, and they remarked that certain localities were extremely hurtful to them, and that in others they were free from all asthmatic symptoms."

I do not like to pass over here a most dramatic tale in the "Psychologie Morbide" of Dr. J. Moreau (de Tours), Médecin de l'Hospice de Bicêtre, Paris, 1859, p. 172. He speaks "of two twin brothers who had been confined, on account of monomania, at Bicêtre. . . . Physically the two young men are so nearly alike that the one is easily mistaken for the other. Morally, their resemblance is no less complete, and is most remarkable in its details. Thus, their dominant ideas are absolutely the same. They both consider themselves subject to imaginary persecutions; the same enemies have sworn their destruction, and employ the same means to effect it. Both have hallucinations of hearing. They are both of them melancholy and morose; they never address a word to anybody, and will hardly answer the questions that others address to them. They always keep apart, and never communicate with one another. An extremely curious fact which has been frequently noted by the superintendents of their section of the hospital, and by myself, is this: From time to time, at very irregular intervals of two, three, and many months, without appreciable cause, and by the purely spontaneous effect of their illness, a very marked change takes place in the condition of the two brothers. Both of them, at the same time, and often on the same day, rouse themselves from their habitual stupor and prostration; they make the same complaints, and they come of their own accord to the physician, with an urgent request to be liberated. I have seen this strange thing occur, even when they were some miles apart, the one being at Bicêtre and the other living at Saint-Anne."

Dr. Moreau ranked as a very considerable medical authority, but I cannot wholly accept this strange story without fuller information. Dr. Moreau writes it in too off-hand a way to carry the conviction that he had investigated the circumstances with the skeptic spirit and scrupulous exactness which so strange a phenomenon would have required. If full and precise notes of the case exist, they certainly ought to be published at length. I sent a copy of this passage to the principal authorities among the physicians to the insane in England, asking if

they had ever witnessed any similar case. In reply, I have received three noteworthy instances, but none to be compared in their exact parallelism with that just given. The details of these three cases are painful, and it is not necessary to my general purpose that I should further allude to them.

There is another curious French case of insanity in twins, which was pointed out to me by Prof. Paget, described by Dr. Baume in the "Annales Médico-Psychologiques," 4me série, vol. i., 1863, p. 312, of which the following is an abstract. The original contains a few more details, but is too long to quote: François and Martin, fifty years of age, worked as railroad-contractors between Quimper and Châteaulin. Martin had twice had slight attacks of insanity. On January 15th a box in which the twins deposited their savings was robbed. On the night of January 23d–24th both François (who lodged at Quimper) and Martin (who lived with his wife and children at St.-Lorette, two leagues from Quimper) had the same dream at the same hour, 3 A. M., and both awoke with a violent start, calling out, "I have caught the thief! I have caught the thief! they are doing mischief to my brother!" They were both of them extremely agitated, and gave way to similar extravagances, dancing and leaping. Martin sprang on his grandchild, declaring that he was the thief, and would have strangled him if he had not been prevented; he then became steadily worse, complained of violent pains in his head, went out-of-doors on some excuse, and tried to drown himself in the river Steir, but was forcibly stopped by his son, who had watched and followed him. He was then taken to an asylum by gendarmes, where he died in three days. François, on his part, calmed down on the morning of the 24th, and employed the day in inquiring about the robbery. By a strange chance, he crossed his brother's path at the moment when the latter was struggling with the gendarmes; then he himself became maddened, giving way to extravagant gestures and making incoherent proposals (similar to those of his brother). He then asked to be bled, which was done, and afterward, declaring himself to be better, went out on the pretext of executing some commission, but really to drown himself in the river Steir, which he actually did, at the very spot where Martin had attempted to do the same thing a few hours previously!

The next point which I shall mention, in illustration of the extremely close resemblance between certain twins, is the similarity in the association of their ideas. No less than eleven out of the thirty-five cases testify to this. They make the same remarks on the same occasion, begin singing the same song at the same moment, and so on; or one would commence a sentence, and the other would finish it. An observant friend graphically described to me the effect produced on her by two such twins whom she had met casually. She said: "Their teeth grew alike, they spoke alike and together, and said the

same things, and seemed just like one person." One of the most curious anecdotes that I have received concerning this similarity of ideas was that one twin A, who happened to be at a town in Scotland, bought a set of champagne-glasses which caught his attention, as a surprise for his brother B; while, at the same time, B, being in England, bought a similar set of precisely the same pattern as a surprise for A. Other anecdotes of a like kind have reached me about these twins.

The last point to which I shall allude regards the tastes and dispositions of the thirty-five pairs of twins. In sixteen cases—that is, in nearly one-half of them—these were described as closely similar; in the remaining nineteen they were much alike, but subject to certain named differences. These differences belonged almost wholly to such groups of qualities as these: The one was the more vigorous, fearless, energetic; the other was gentle, clinging, and timid; or, again, the one was more ardent, the other more calm and gentle; or again, the one was the more independent, original, and self-contained; the other the more generous, hasty, and vivacious. In short, the difference was always that of intensity or energy in one or other of its protean forms: it did not extend more deeply into the structure of the characters. The more vivacious might be subdued by ill health, until he assumed the character of the other; or the latter might be raised by excellent health to that of the former. The difference is in the key-note, not in the melody.

It follows, from what has been said concerning the similar dispositions of the twins, the similarity in the associations of their ideas, of their special ailments, and of their illness generally, that the resemblances are not superficial, but extremely intimate. I have only two cases altogether of a strong bodily resemblance being accompanied by mental diversity, and one case only of the converse kind. It must be remembered that the conditions which govern extreme likeness between twins are not the same as those between ordinary brothers and sisters (I may have hereafter to write further about this); and that it would be wholly incorrect to generalize, from what has just been said about the twins, that mental and bodily likeness are invariably coördinate, such being by no means the case.

We are now in a position to understand that the phrase "close similarity" is no exaggeration, and to realize the value of the evidence about to be adduced. Here are thirty-five cases of twins who were "closely alike" in body and mind when they were young, and who have been reared exactly alike up to their early manhood and womanhood. Since then the conditions of their lives have changed: what change of conditions has produced the most variation?

It was with no little interest that I searched the records of the thirty-five cases for an answer; and they gave an answer that was not altogether direct, but it was very distinct, and not at all what I

had expected. They showed me that in some cases the resemblance of body and mind had continued unaltered up to old age, notwithstanding very different conditions of life; and they showed in the other cases that the parents ascribed such dissimilarity as there was, wholly, or almost wholly, to some form of illness. In four cases it was scarlet fever; in one case, typhus; in one, a slight effect was ascribed to a nervous fever: then I find effects from an Indian climate; from an illness (unnamed) of nine months' duration; from varicose veins; from a bad fracture of the leg, which prevented all active exercise afterward; and there were three other cases of ill health. It will be sufficient to quote one of the returns; in this the father writes:

"At birth they were *exactly* alike, except that one was born with a bad varicose affection, the effect of which had been to prevent any violent exercise, such as dancing or running, and, as she has grown older, to make her more serious and thoughtful. Had it not been for this infirmity, I think the two would have been as exactly alike as it is possible for two women to be, both mentally and physically; even now they are constantly mistaken for one another."

In only a very few cases is there some allusion to the dissimilarity being partly due to the combined action of many small influences, and in no case is it largely, much less wholly, ascribed to that cause. In not a single instance have I met with a word about the growing dissimilarity being due to the action of the firm free-will of one or both of the twins, which had triumphed over natural tendencies; and yet a large proportion of my correspondents happen to be clergymen whose bent of mind is opposed, as I feel assured from the tone of their letters, to a necessitarian view of life.

It has been remarked that a growing diversity between twins may be ascribed to the tardy development of naturally diverse qualities; but we have a right, upon the evidence I have received, to go further than this. We have seen that a few twins retain their close resemblance through life; in other words, instances do exist of thorough similarity of nature, and in these external circumstances do not create dissimilarity. Therefore, in those cases, where there is a growing diversity, and where no external cause can be assigned, either by the twins themselves or by their family for it, we may feel sure that it must be chiefly or altogether due to a want of thorough similarity in their nature. Nay, further, in some cases it is distinctly affirmed that the growing dissimilarity can be accounted for in no other way. We may therefore broadly conclude that the only circumstance, within the range of those by which persons of similar conditions of life are affected, capable of producing a marked effect on the character of adults, is illness or some accident which causes physical infirmity. The twins who closely resembled each other in childhood and early youth, and were reared under not very dissimilar conditions, either

grow unlike through the development of natural characteristics which had lain dormant at first, or else they continue their lives, keeping time like two watches, hardly to be thrown out of accord except by some physical jar. Nature is far stronger than nurture within the limited range that I have been careful to assign to the latter.

The effect of illness, as shown by these replies, is great, and well deserves further consideration. It appears that the constitution of youth is not so elastic as we are apt to think, but that an attack, say of scarlet fever, leaves a permanent mark, easily to be measured by the present method of comparison. This recalls an impression made strongly on my mind several years ago by the sight of a few curves drawn by a mathematical friend. He took monthly measurements of the circumference of his children's heads during the first few years of their lives, and he laid down the successive measurements on the successive lines of a piece of ruled paper, by taking the edge of the paper as a base. He then joined the free ends of the lines, and so obtained a curve of growth. These curves had, on the whole, that regularity of sweep that might have been expected, but each of them showed occasional halts, like the landing-places on a long flight of stairs. The development had been arrested by something, and was not made up for by after-growth. Now, on the same piece of paper my friend had also registered the various infantine illnesses of the children, and corresponding to each illness was one of these halts. There remained no doubt in my mind that, if these illnesses had been warded off, the development of the children would have been increased by almost the precise amount lost in these halts. In other words, the disease had drawn largely upon the capital, and not only on the income, of their constitutions. I hope these remarks may induce some men of science to repeat similar experiments on their children of the future. They may compress two years of a child's history on one side of a ruled half-sheet of foolscap paper if they cause each successive line to stand for a successive month, beginning from the birth of the child; and if they mark off the measurements by laying, not the 0-inch division of the tape against the edge of the pages, but, say, the 10-inch division—in order to economize space.

The steady and pitiless march of the hidden weaknesses in our constitutions, through illness to death, is painfully revealed by these histories of twins. We are too apt to look upon illness and death as capricious events, and there are some who ascribe them to the direct effect of supernatural interference, whereas the fact of the maladies of two twins being continually alike shows that illness and death are necessary incidents in a regular sequence of constitutional changes, beginning at birth, upon which external circumstances have, on the whole, very small effect. In cases where the maladies of the twins are continually alike, the clock of life moves regularly on, governed by internal mechanism. When the hand approaches the hour-mark,

there is a sudden click, followed by a whirring of wheels; the moment that it touches it, the stroke falls. Necessitarians may derive new arguments from the life-histories of twins.

We will now consider the converse side of our subject. Hitherto we have investigated cases where the similarity at first was close, but afterward became less; now we will examine those in which there was great dissimilarity at first, and will see how far an identity of nurture in childhood and youth tended to assimilate them. As has been already mentioned, there is a large proportion of cases of sharply-contrasted characteristics, both of body and mind, among twins. I have twenty such cases, given with much detail. It is a fact that extreme dissimilarity, such as existed between Esau and Jacob, is a no less marked peculiarity in twins of the same sex, than extreme similarity. On this curious point, and on much else in the history of twins, I have many remarks to make, but this is not the place to make them.

The evidence given by the twenty cases above mentioned is absolutely accordant, so that the character of the whole may be exactly conveyed by two or three quotations. One parent says: "They have had *exactly the same nurture* from their birth up to the present time; they are both perfectly healthy and strong, yet they are otherwise as dissimilar as two boys could be, physically, mentally, and in their emotional nature." Here is another case: "I can answer most decidedly that the twins have been perfectly dissimilar in character, habits, and likeness, from the moment of their birth to the present time, though they were nursed by the same woman, went to school together, and were never separated till the age of fifteen." Here again is one more, in which the father remarks, "They were curiously different in body and mind from their birth." The surviving twin (a senior wrangler of Cambridge) adds: "A fact struck all our school contemporaries, that my brother and I were complementary, so to speak, in point of ability and disposition. He was contemplative, poetical, and literary to a remarkable degree, showing great power in that line. I was practical, mathematical, and linguistic. Between us we should have made a very decent sort of a man." I could quote others just as strong as these, while I have not a single case in which my correspondents speak of originally dissimilar characters having become assimilated through identity of nurture. The impression that all this evidence leaves on the mind is one of some wonder whether nurture can do any thing at all beyond giving instruction and professional training. It emphatically corroborates and goes far beyond the conclusions to which we had already been driven by the cases of similarity. In these, the causes of divergence began to act about the period of adult life, when the characters had become somewhat fixed; but here the causes conducive to assimilation began to act from the earliest moment of the existence of the twins, when the

disposition was most pliant, and they were continuous until the period of adult life. There is no escape from the conclusion that nature prevails enormously over nurture when the differences of nurture do not exceed what is commonly to be found among persons of the same rank of society and in the same country. My only fear is, that my evidence seems to prove too much, and may be discredited on that account, as it seems contrary to all experience that nurture should go for so little. But experience is often fallacious in ascribing great effects to trifling circumstances. Many a person has amused himself with throwing bits of stick into a tiny brook and watching their progress; how they are arrested, first by one chance obstacle, then by another; and again, how their onward course is facilitated by a combination of circumstances. He might ascribe much importance to each of these events, and think how largely the destiny of the stick had been governed by a series of trifling accidents. Nevertheless all the sticks succeed in passing down the current, and they travel, in the long-run, at nearly the same rate. So it is with life in respect to the several accidents which seem to have had a great effect upon our careers. The one element, which varies in different individuals, but is constant in each of them, is the natural tendency; it corresponds to the current in the stream, and inevitably asserts itself. More might be added on this matter, and much might be said in qualification of the broad conclusions at which we have arrived, as to the points in which education appears to create the most permanent effect: how far by training the intellect, and how far by subjecting the boy to a higher or lower tone of public opinion; but this is foreign to my immediate object. The latter has been to show broadly, and, I trust, convincingly, that statistical estimation of natural gifts by a comparison of successes in life is not open to the objection stated at the beginning of this memoir. We have only to take reasonable care in selecting our statistics, and then we may safely ignore the many small differences in nurture which are sure to have characterized each individual case—*Frazer's Magazine.*

THE FORMATION OF SAND-DUNES.

By E. LEWIS, Jr.

ON the south shore of Long Island there intervenes between the uplands and the ocean a narrow beach on which the waves continually break. It is composed chiefly of clean, grayish-white, silicious sand. Other matters present are mica, garnet, and magnetic-iron sands, but, excepting a few localities, these are not in quantity sufficient to alter the general character of the beach. The sand-grains

are small; some of them exceedingly minute. We found, in specimens of drifted sand, 1,920 particles in the weight of a troy grain. This will give, for a pound avoirdupois, more than 13,000,000, and about 1,450,000,000 in a cubic foot of sand. The comparison of a "great multitude" to the "sands of the sea-shore" is wonderfully vivid and impressive. Examined by the aid of a microscope, these delicate grains are seen to have lost the sharp, angular features of broken quartz, and closely resemble pebbles, irregular in form, but smooth and rounded. They are wave-worn bowlders on a small scale.

This beach, which is seldom more than one-third of a mile broad, constitutes the coast-line from Coney Island at the entrance to New York Harbor, to the Nepeague Hills, a distance of about one hundred miles, but broken by occasional inlets through which the tides ebb and flow. Throughout this distance, scarcely a pebble of any considerable size occurs. Mather, in the "Geological Survey of the State of New York," commenting on this magnificent beach-line, says, "In Europe, there is no deposit of a similar character to compare with it in extent."

Eastward from the Nepeague hills, which are of sand, along the ocean-side of Montauk Point, high bluffs of bowlder-drift reach the shore, strewing it with their falling *débris*. Here may be seen on a grand scale the process by which rocks are transformed into the fine sand of which the beach is composed. The waves throw their whole force upon the shore, carrying forward with tremendous roar tons of bowlders and pebbles which roll back as the waves recede. This process is repeated with every wave. The stones thus rolled and tossed lose something of their volume, and scarcely one can be found that does not show signs of disintegration and decay. All of them are penetrated by moisture, some are fractured by frost, and others, weakened by chemical changes, are dashed in pieces. The sand-beach represents the silicious matters of these comminuted rocks. Its position along the coast is determined by the set of the waters, but its contour of sand-hills is determined by winds. These, in their endless play, have carved it into every form possible to drifting sands. Mather observed that "where the beach is above the reach of the surf, it is covered by a labyrinth of hillocks of drifting sand, imitating almost all the varieties of form which snow-drifts present after a storm." These are sand-dunes, or dunes, as they are termed by Lyell, and their surprising mobility, in the ever-changing direction and force of the winds, is a subject of scientific and popular interest.

Everywhere on the beach, in a dry, windy day, the sand-grains on the surface are in motion. They are not carried through the air like dust, except to a limited extent, when the winds are violent, but roll or bound along the surface. Their motion, therefore, represents to the eye, although less perfectly than snow or dust, the motions of the invisible air.

The dunes are built up by slow accretions, and at the top the sand-grains are smaller than at the bottom. The process by which they are formed is a continual rolling of sand-grains up-hill by wind-force, and it is obvious that the lightest ones will attain the greatest elevation. These, too, are the ones that, on reaching the top of the hillock, roll over on the protected side of the dune, and there form a mass of fine sand. But the winds are not uniform in force, and a consequence is, the dunes are laminated in their structure, coarse and fine layers alternating. The winds change in direction too, changing the position of the sands, and thus the dunes are not only laminated, but irregularly bedded in their structure, closely resembling in this respect that of beaches formed by the plunge and flow of waves. Both structures simply represent wave-motions, one of the water, the other of the air. Fig. 1 represents a section of a large sand-dune, and Fig. 2 a similar but coarser formation hardened into sandstone.

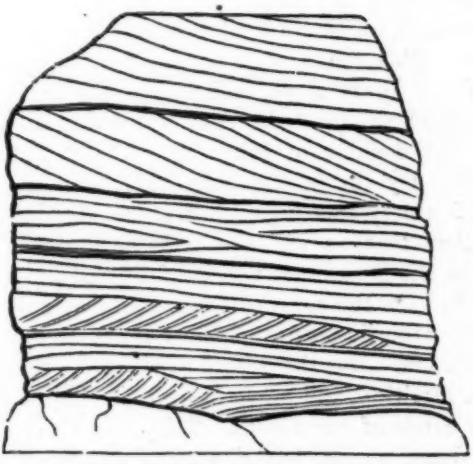


FIG. 1.—SECTION OF A SAND-HILL, THE STRUCTURE OF WHICH MAY HAVE BEEN PRODUCED BY THE ACTION OF WAVES OR WIND.

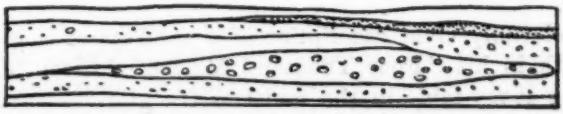


FIG. 2.—SECTION OF STRATA OF SANDSTONE.

The exterior form of a dune undergoes continual change in dry weather from gravity. The grains of sand roll down its sides until the fine traces of wind-sculpture are obliterated, and a somewhat uniform outline is obtained. It is found that in case of dry sand the angle the side of the dune will finally assume is about 32°. But the winds rarely permit regularity in the form of dunes. A slight breeze becomes a strong one when it rises to the top of an obstacle, or is

turned around it, and every dune, however small, becomes a means of so distributing the air-waves that their force and eroding power are increased. From these and similar causes, the contour of the mobile sand-hills is scarcely more permanent than that of the waves in whose spray they lie. But it is the dry sand only that is put in motion by the winds; only a few inches below the surface it is uniformly moist, and on that account somewhat adhesive. This moisture above where the sand is saturated is capillary water, that is, water held by the attraction of the sand-grains, and is about thirty per cent. of the mass by weight. It rises through the sand to the surface as evaporation goes on, and thus in this climate of rainfall the dunes are rendered more permanent than on rainless deserts.

The formation of a sand-dune seems a simple process, and it is surprising how small an object may be the nucleus of one, and indirectly of a series of them. A bush, or tuft of grass, or only a twig, as we have seen, raised above a level surface, breaks the force of the wind, and immediately the sand-grains, which are rolling along the surface, are arrested, and form a minute hillock on the windward side of the obstacle. This increases in size—the sand-grains, as before observed, are driven up its slope, and fall on the sheltered side. The mound thus formed produces currents and eddies in the moving air, and the form and position of other hillocks are determined by the new conditions. By the means indicated, dunes are formed on our narrow beaches thirty feet high; but there are dunes on our coast much higher than that, as will presently be noticed. Their size depends mainly on the abundance and condition of the material, and exposure to winds. On the coast of France they attain a height of 225 feet, and on the Atlantic border of the Sahara Desert are more than twice that elevation. But the desert sands are exceedingly fine and dust-like from attrition, and move in greater volume than is possible for the coarser sands of our coasts. They are whirled and tossed in the gale like dense smoke, but nowhere do they roll on as do waves of the ocean, as is sometimes stated. The transition of a sand-dune is by transfer and deposition of the individual particles of which it is composed.

A wonderfully vivid description of a sand-storm is given by Mr. Southworth, in his "Four Thousand Miles of African Travel:" "I was sitting at my table in the midst of the glorious sunshine of Africa. Slowly the southern horizon began to grow obscure. A huge mountain of sand, growing grander and grander, advanced rapidly. . . . The doom-palms and date-trees, frosted with clouds of white birds, the spires and minarets slowly losing their outlines in the dense obscurity. . . . It came nearer and nearer. Its front was absolutely perpendicular. To breathe was difficult and oppressive, and it was darker than the darkest night I ever knew. Sand covered the ground to the thickness of an inch."

It is easy to see that this more accurately describes a dust-storm than it does the movement of sand on our beaches. It is the fine material only which is thus swept through the air. The coarser sands are driven along the surface, and constitute the hills of the desert, and they are built up as similar ones are of the still coarser sands of our coast. Grain by grain they rise at the touch of the invisible architect. This is true not only of the great dunes, but of the smaller ones, or ripple-marks, which cover the surface of the sands. These beautifully cut and wavy furrows represent the undulatory movement of the air. With a full breeze, they are all seen to be in motion. The grains hop and bound along as the air passes, and the form shown in Fig. 3 is the one which the sands continually assume. But, even while

FIG. 3.

we watch, each little ridge or mound has been transferred to the space which was a furrow only a few moments before.

These sand-ripples rise on the sandy floor, however level and smooth they may be, as the wind in passing strikes it, in a series of wave-like undulations.

Ripple-marks thus formed are, sometimes, as we have witnessed, covered by drifting sand, and are retained with wonderful distinctness, when the material is hardened into sandstone. All the vast beds of this material existing in the crust of the globe are but the compacted ruins of rock still older, and their furrowed tablets repeat to our eyes the rhythmic beat of winds and waters in ages long past. Fig. 4 represents a slab of sandstone covered with ripple-marks, evidently produced by water, but which differs in form only from those produced by wind.

Sand-dunes are not only blown away piecemeal, but the winds pour upon their flanks a ceaseless shower of sand, and, as the frail masonry gives way, the falling grains are caught and carried on by the gale. By this natural sand-blast rocks are sculptured on the highlands of the Rocky Mountains, and the glass of windows on exposed beaches is sometimes cut through.

On the north side of Long Island, upon the banks along the Sound, are a great number of sand-hills from twenty to eighty feet high. The banks are of glacial drift, with bowlders of immense size, and eastward of Port Jefferson Harbor, for upward of forty miles, are crowned in many places by these broken, desolate hills. In some places they advance slowly inland. A farm, near the village of Baiting Hollow, in Suffolk County, has lost from this cause thirty acres in half a century. Other farms have lost valuable land in a similar way, and we are informed that, during the time mentioned, 100 acres of arable and tim-

ber land have been inundated, and are now deeply covered with drifting sand in this immediate neighborhood. At this point is the great dune known on the Coast Survey charts as Friar's Head. Its top is 150 feet above tide, but it stands on the bank which is half that height, so that 75 feet of that elevation is drifting sand. It was originally formed many yards inland, as others are continually

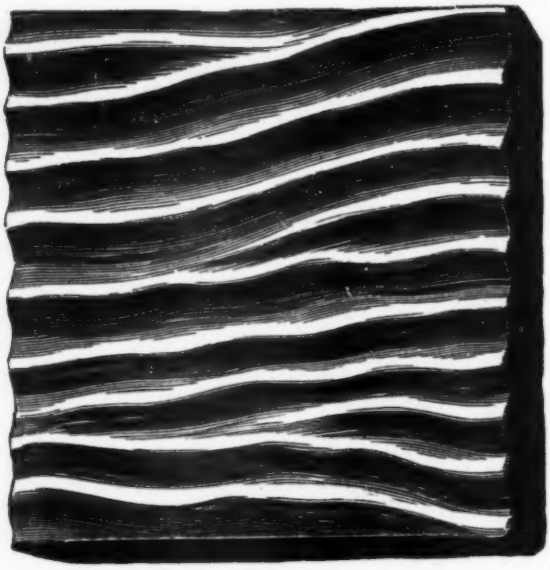


FIG. 4.—SLAB OF RIPPLE-MARKED SANDSTONE.

forming, but, by the ceaseless wearing away of the bluffs, it is now upon their brink. It is evidently of considerable age, as its windward slope is covered by a thick growth of beach-grass, bayberry and other bushes, with stunted trees of beach and cedar quite at its top.

From this point the weird architecture of the sand-hills is singularly impressive. There is formed, to the southeast of Friar's Head, a great semicircle of sand, between which and the dune is a floor of several acres in extent swept by the winds. This floor, the original surface of the drift now laid bare, is rich in the remains of an old Indian settlement. Hundreds of specimens—including arrow-heads of flint, jasper, and quartz, axes of various sizes, and other articles of utility—have been picked up.

The sand blown from this spot and from the flanks of the dune constitutes the semicircular wall spoken of. It is one-eighth of a mile inland, and lies directly against a forest of oak and pine, burying many of the trees to a height of thirty to forty feet, only their dead and barkless tops being visible. On the surface of these sands beach-grass of several kinds, and young pine-trees (*Pinus rigida*) maintain

a doubtful struggle for life. This dune does not materially differ from a very large number which cover the banks on the north shore of Long Island. Their source is the *débris* of the banks reduced to sand by the action of the waves. The lighter portions of this sand are carried up the slope during fierce winds, and the process is now in operation during every gale. The present forests may delay, but cannot arrest, the final inundation of the land where the sand-hills crown the coast. In Europe the maritime pine and other species of plants whose habitat is the silicious sand have not only arrested the movement of it, but have covered immense areas of waste land with valuable forest. Our native pitch-pine, the *Pinus rigida* above mentioned, also flourishes on the most sandy soils. There is proof that it formerly grew on portions of the south beach of Long Island, where its foliage was moistened by the spray of the ocean, nor does the occasional overflow of the tides soon destroy it. If these trees are planted abundantly over the surface of these broken hills of sand, their movement would be delayed if not permanently arrested. The sands lie motionless where the force of the wind is broken.

SKETCH OF SIR CHARLES WHEATSTONE.

CHARLES WHEATSTONE was born in the city of Gloucester, England, in 1802. In boyhood he attended a private school in his native town, but, while still a lad, he quit school and devoted himself to mechanical pursuits, adopting the trade of a maker of musical instruments. At about the age of twenty-one years he went to London, and there set up in business on his own account. Here the young tradesman evinced a strong liking for scientific research, endeavoring to find out the principles involved in the various forms of musical instruments. He was thus led to the study of acoustics, a branch of science which he cultivated with rare success. His singular mechanical ingenuity enabled him to repeat and extend the experimental results of prior investigators, and the first fruits of his scientific researches were communicated, in 1823, to the *Annals of Philosophy*, in a paper entitled "New Experiments on Sound." Other essays on the phenomena of sound were published by him from time to time; thus, in 1827, he contributed to the *Quarterly Journal of Science* two papers, the one "Experiments on Audition," the other a "Description of the Kaleidophone." In 1828 he published in the same journal a paper entitled "Resonances of Columns of Air;" in 1831, "Transmission of Sounds through Solid Linear Conductors" (*Journal of the Royal Institution*); and the same year read at the meeting of the Brit-

ish Association papers on "Purkinje's Figures," and on "Bernouilli's Wind Instrument." These were followed by papers on "Chladni's Figures" (1833, "Philosophical Transactions"), and "Imitation of Human Speech by Mechanism" ("British Association Report," 1835).

The numerous analogies between the phenomena of sound and those of light early led him to the study of the latter subject. Here, again, his remarkable ingenuity as a mechanician came into play. He undertook to measure the velocity of electricity, and for this purpose he invented the method of revolving mirrors; in this way it was shown that the electric current travels at the rate of 288,000 miles per second. These results were published in the "Philosophical Transactions" in 1834. While engaged in these researches he observed that the sparks emitted from different metals under the influence of electricity differed from one another in color, "thus shadowing forth," says M. Dumas, "the discovery of the spectroscope." In the "British Association Report" for 1835 is a paper by Wheatstone on "Prismatic Decomposition of Electric Light," and in the *Philosophical Magazine* (1837) one on the "Thermo-electric Spark." He had been appointed Professor of Experimental Philosophy in King's College, London, in 1834, and in June, 1836, in his lectures on the velocity of electricity, which were illustrated by experiments with a circuit of copper wire nearly four miles in length, he proposed to convert this apparatus into an electric telegraph. At this time Wheatstone was not aware that Prof. Joseph Henry had five years previously transmitted signals by means of an electro-magnet through a wire more than a mile long, causing a bell to sound at the farther end of the wire. In May, 1837, Charles Wheatstone and William Fothergill Cooke (afterward knighted) took out a patent "for improvements in giving signals and sounding alarms in distant places by means of electric currents transmitted through metallic circuits." The first public line of telegraph was constructed on the Blackwall Railway in the following year.

While investigating the laws of light, Wheatstone was very naturally led to consider the phenomena of vision, and in 1838 he published in the "Philosophical Transactions" two papers entitled "Physiology of Vision" and "Binocular Vision." In the latter he explained the principles of an instrument invented by himself, the stereoscope. This invention was by no means the result of chance, but the fruit of profound study of the physiology of vision. In this matter Wheatstone's merit is unquestioned. Other papers on the phenomena of vision are, "Juxtaposition of Several Colors" (1844); a second communication on "Physiology of Vision" (1852); "Binocular Microscope" (1853); "Fessil's Gyroscope" (1854).

In the "Proceedings of the Royal Society" (1840) is an article by Wheatstone, on an "Electro-magnetic Clock," in which he shows how a number of clocks, situated at a distance from one another, may be act-

uated by one central clock. In *Comptes Rendus* (1845), he explained the principle of an electro-magnetic chronoscope. Subjects connected with telegraphy and electricity are treated in papers entitled "Electro-magnetic Telegraph" (1840); "Constants of Voltaic Circuit" (1843); "Meteorological Registers" (1844); "Submarine Cable of the Mediterranean" (1854–'55); "Aluminium in Voltaic Series" (1854–'55); "Automatic Telegraphy" (1859). To complete the list of his papers, we name a "Letter to Colonel Sabine on Meteorological Instruments" (1842); "Determination of Solar Time by Polarization" (1848); "Foucault's Rotation of the Earth" (1851); "Powers for Arithmetical Progression" (1854–'55); "Report on Captive Balloons" (1863).

Wheatstone was chosen Fellow of the Royal Society of London in 1836. He was a juror in the class for heat, light, and electricity in the Paris Exposition Universelle, 1855, and was then appointed a knight of the Legion of Honor. In 1868 he received the honor of knighthood from Queen Victoria, and the same year was awarded the Copley medal by the Royal Society for his researches in acoustics, optics, electricity, and magnetism. He was made LL. D. by Edinburgh University in 1869. In 1873 he was elected a corresponding member of the Paris Académie des Sciences, in the place of Baron Liebig, deceased. He was also a member of the chief scientific associations and academies of Europe.

Prof. Wheatstone was married in 1845. His death took place at Paris, on the 19th of October, 1875. He left a numerous family.

In a brief memoir published in the *Academy*, Mr. C. Tomlinson, who was an intimate friend of Wheatstone, states that the latter never obtained eminence either as a writer or as a lecturer: before a large audience he was nervous and hesitating, but in familiar conversation his ideas "would flow so pleasantly and so lucidly, that one could not help reflecting that, if all this had been put into a lecture, Wheatstone might have become a successful rival even of Faraday." On such occasions he spoke unreservedly of the scientific work in which he happened to be engaged, and in this way other men often pilfered his ideas, and took the credit to themselves. On one occasion at least, Wheatstone recognized his error, for he paid ten guineas for a piece of apparatus for the purpose of stopping the inventor's mouth, said "inventor" having derived the idea of it from Wheatstone himself.

CORRESPONDENCE.

INFIRMITIES OF SPEECH.

To the Editor of the Popular Science Monthly:

THE article in the August number of the MONTHLY upon "Infirmities of Speech" was a stimulant to much curious reflection. A true student of character will see, among the men and women he meets in the parlor, idiosyncrasies of speech and manner that are common to quite a large class of people. Dr. Trousseau's patient was but one of many. The wife of a physician of this city, formerly an inspector of the Board of Health, created much merriment among acquaintances by the singularity of her answers to the simplest questions. Nearly every expression was a comparative one. To a stranger her conversation appeared of the quality of humorous extravagance. Upon one occasion she was asked the condition of a friend who had been a long time sick. "Oh, she's about like the lid of a stove," was the reply. This excited laughter, but was unsatisfactory. "Was she feverish?" "No." "Was she in a chill?" "No, she was just like the lid of a stove, don't you understand?" Her husband explained the expression by saying that the sick friend was exceedingly *nervous*, and that his wife, in making the comparison, alluded to the dancing of a tea-kettle on a hot stove. From early girlhood she had employed this expression, to the exclusion of the correct one.

In their reminiscences, Charles and Mary Cowden Clarke mention a similarity in the speech of George Dyer. With a question, answer, or other observation, he would begin intelligently; after a few words, fill in the space of several others with a series of abd's, as if choking, and, in concluding, would invariably use "Well, sir, but, however." A gentleman of rich culture and high professional eminence has used "and consequently" since he was a boy, whenever he exhausted breath in his rapid speech, was unable to grasp the correct word, or was interrupted. He was, and still is, unconscious of this peculiarity. He will so designate a man, a woman, a piece of furniture, or any object whose proper name is for the time hidden. This habit, as the untutored would denominate it, is so apparent that a stranger would detect it in five minutes.

The ability to always use the best words to give force to an idea is possessed by so few, that the promiscuous gathering of words, if not too idiotic, is charitably passed over without remark.

A young lady, whose company is much solicited for the graces of her mind, undergoes a most piteous embarrassment from the effects of this infirmity. In the early part of the evening her choice of words will be faultless; and she will render a criticism or narrative with an enviable flow. But, later, she becomes nervous, hesitates, studies her words, trips, and then stumbles on to the climax with nouns, adjectives, adverbs, and verbs that darken, instead of illumine, the "point." It is but a few evenings ago that, in speaking of the influence of Hans Christian Andersen's tales, she said: "Now, how few writers are capable of so effectively consolidating the contradictory impulses that arise in a child's mind! No, I mean so effectively con—con—well, mix up will oil." And, when *conciliate* was mentioned, she said that was the word she desired. If she ventured upon a further observation the infirmity increased, so far as to leave her sentence a hopeless wreck.

Many will say this is a habit, and only becomes an infirmity by being allowed too free scope. Still, the best-educated people are subject to it.

To carelessness is attributed another peculiarity, not of speech, but of action. The physician before alluded to was unable to page his manuscript of stenographic reports of lectures before the College of Physicians and Surgeons. The figure 8 was always uppermost in his mind, and all but the first page would have that numeral in the upper left-hand corner. When arranging the pages for eyelets or tape, he was

obliged to read over each one; and he was not assured of the sequence until the mass had been examined by another.

Some writers fasten their best thoughts when penning with the greatest haste. Their manuscript, like that of many careful authors, contains either neglected or erased words—terminations that appear perfectly inexcusable. Think of a scholar tracing with a rush *fixed*, and then adding *tion*, or satisfying himself with *hermeticly;* and yet, in overlooking thousands of pages of copy prepared by authors who would have a delirium if the slightest typographical error appeared in the "revise," I have stricken out countless terminations and intermediate syllables and letters—not specimens of bad spelling, so called—that looked like grammatical refugees, so far were they from their proper place.

Again, in writing, the pen does apparently just what the organs of speech do when certain words are to be produced. In the most delightful stage of composition, when the brain and the pen jog on comfortably together, it will often be found, on looking back a few lines, that a stranger has turned up who the author is positive has no right in such company. There it is, winking at a clever trick that the subject cannot explain.

Here the writer possesses the memory of words and the memory of how to use words. But, while the mind is being tickled with the successful unfolding of a pet theory, or the attractive draping of an important idea, the pen surreptitiously lets in an unblushing beggar.

In writing, the brain will order the pen to inscribe a certain word, and, with voluminous authors, that nimble servant will frequently transfix an unsuspected one before the outrage is detected.

Now, as in the case above, the author possesses the knowledge of the exact word that is desired; but an incorrect one appears. Neither the memory is lost, nor the ability of utilizing it. Think of the results, when the proof-reader strides through the idea, and buries a still more uncongenial word in the prettiest passage.

Recognized carelessness causes omission of words, curtailment of words, and oftentimes incorrect spelling. It is only the carelessness that is not recognized that takes a fancy to giving a word more letters than it craves, changing favorite words at birth, and placing before the eye a stone when bread is wanted.

G. J. HAGAR.

NEW YORK, *August*, 1875.

EDITOR'S TABLE.

THE CASE OF GUIBORD.

ALL over the world, in all times of which we know any thing, and among tribes of men of every grade, the most intense and powerful feelings of human nature have gathered around the dead, the graves where they are buried, and the rites of sepulture. Besides the ties of affection that are sundered by death, and which are often so deep and strong that their rupture leaves life a desolation, the imagination is also brought into exalted activity, and religious hopes, fears, and anxieties, and the terrors of superstition regarding a future life, combine to heighten the solemn interest of the occasion. As men are ruled through their feelings, and as the more powerful the feelings the more complete is their subjection to those who can skillfully work upon them, it is not to be supposed that these potent emotions concerning the dead would remain unutilized by parties ambitious of influence over the consciences and conduct of men. It is an important part of the polity of the Roman Catholic Church to use the powerful sentiments that are associated with death, the dead body, and the grave in which it rests, for the promotion of the objects of ecclesiastical ambition. That corporation assumes the prerogative of consecrating or cursing the ground to be

used for the burial of the dead, as a part of its larger claim to control the destiny of people in the future world. And, for many centuries, this has been one of the most potent means of its influence. The case of Joseph Guibord, of Montreal, which has now perhaps reached its close, affords an instructive illustration both of the character of this old churchly assumption, of the tenacity with which it is still held, and of the vigor with which it is maintained wherever there is power to enforce it. The circumstances have been widely published, but it is desirable here briefly to recall the leading facts:

A literary society in Montreal, known as the "Canadian Institute," some years ago introduced into its library a number of works that came under the ban of the Roman Catholic Church. The Bishop of Montreal disapproved them and commanded their exclusion, which being refused by the Institute, the bishop appealed to Rome, and a papal decree was fulminated. The society remaining contumacious, the bishop pronounced a ban upon its members excommunicating them and forbidding them the last offices of the Church in "the article of death." The consequences of this decree first fell upon Guibord, who died in 1869. His estate owned a burial-lot in the Catholic cemetery of Notre-Dame, and the widow applied for ecclesiastical burial for her husband. This was refused: he could not be buried in his own lot, and the only place permitted for the remains was the unconsecrated part of the cemetery devoted to excommunicants, malefactors, suicides, and unbaptized infants. The case was then taken to civil trial and a long lawsuit followed; the Canadian Superior Court, the tribunal of last resort, deciding ultimately against the priest and trustees of the cemetery. This decision not being respected by the Catholic authorities, an appeal was taken to the Privy Council, and a royal decree issued commanding the priest and trustees of the cemetery to inter the mortal remains of Guibord in consecrated ground. The priest replied that he was forbidden to do this by the bishop, and could not comply. An order was then served on him under the decree of the Privy Council, and the funeral appointed for the 2d of September. The priest, however, refused to be present. The members of the "Canadian Institute" and their friends, numbering about three hundred, accompanied Guibord's remains, from the vault of the Protestant cemetery where they had been placed, to the Catholic cemetery, where they were met by a mob of some five hundred French Canadians who closed and barred the gates, and refused entrance to the hearse, which was attacked with stones by the mob that had rapidly increased to about two thousand. They drove back the procession with derisive shouts, filled up the grave, and tore down the cross at its head.

The burial was thus defeated, and riotous demonstrations were continued for two or three days. Preparations were then made by the civil authorities for enforcing the burial, the military were called out to maintain order, and on the 16th of November, after six years of contention and delay, the body of Guibord was placed in his lot, the coffin being bedded in cement as a protection against the violation of the grave.

We do not refer to these facts merely as furnishing a new example of the inevitable collision that arises between the civil authority and the Roman Catholic Church wherever that organization feels able to assert its power—of which so much has recently been said. But the case impressively illustrates a single and most interesting phase of this ancient conflict. In the attempt to get the bones of an old man, long since dead, into their final and chosen resting-place, a city is convulsed with riot, a whole province thrown into excite-

ment, a rancorous religious quarrel aroused, expensive legal proceedings entailed, and battalions of soldiers with muskets and cannon, have at last to be invoked to carry out the mandate of a judicial tribunal. All this has resulted from the action of an ecclesiastical body which for centuries has pursued this policy of using the graveyard and its associated superstitions as a means of spiritual domination and temporal profit. Guibord was in favor of having certain books in a library to read. His Church declared that he should not have them there. He adhered to his opinion, and the Church then declared that he should not have Christian burial. The appeal to his superstitions was not strong enough to move him, but it thrilled the community with a painful agitation, and for many centuries such appeals and threats have been powerful enough to intimidate and keep in subjection countless millions of people. For more than a thousand years the Catholic Church has maintained its claim, against the civil authority, to the ownership and custody of the dead, and by attaching the place of interment to the church, by prohibiting heretics from Christian burial and making it ignominious to repose in any but consecrated earth, and by digging up the bones of those who are alleged to have entertained false opinions, burning them and scattering the ashes to the winds or casting them into the floods, the Romish ecclesiastics have not only made the church-yard a copious source of pecuniary emolument, but "a vital portion of the material machinery for enforcing spiritual obedience and theological conformity."

The history of the antagonism between the ecclesiastical and civil authorities, regarding the ownership and control of the dead, is of great interest; and a very able sketch of this subject by an eminent legal writer will be found in the present number of THE MONTHLY. It is part of a report on the "Law of Burial" made to the Supreme Court of the State of New York, by Hon. Samuel B. Ruggles. When Beekman Street was widened several years ago, a slice of land was taken from the "Brick Church" property to be converted to public use, and the ground thus appropriated embraced certain vaults long ago constructed for the reception of the dead. The question arose in regard to the legal control and redisposition of the bodies contained in these vaults, and Mr. Ruggles was appointed as a referee to take evidence and make a report upon the subject. In this masterly document, he touched upon the historical aspects of the legal question, showing that the old view, held by the Roman and Saxon law, was that the civil authority had jurisdiction in the case, and that under the common law the bodies of deceased persons are subject to the control of those next of kin. The Church, early in the days of its power, subverted this principle, and under the title of "ecclesiastical cognizance" established its exclusive authority over the burial of the dead, and even carried its assumptions so far as to decree, not only who should be allowed to lie in consecrated earth, but who should be allowed to be interred at all! The part of Mr. Ruggles's report which we reprint will be found of general interest to readers, and in a high degree instructive in connection with the Guibord case.

SCIENCE IN GERMANY AND ENGLAND.

THE influence of national characteristics upon the pursuit of science is an interesting subject of observation and reflection. For while there is a broad general agreement among scientific students of all nationalities as to what science is, and the mental methods or processes involved in its extension, there is a marked diversity among the people of different countries in the organized arrangements for its promotion, the feelings that impel its pursuit, and

the relations of scientific bodies to what may be called the outlying and adjoining departments of thought, culture, and mental activity. The contrast, for example, between the Germans and the English in the policy and management of their great popular scientific associations is, in various respects, striking and instructive, and an intelligent correspondent of *Nature* has lately drawn attention to some of their peculiarities, which are so suggestive as to deserve a special notice.

The writer intimates that the "Association of German Natural Philosophers and Physicians," which was founded in 1822, is the original of the British Association, which was established some years later, and modeled in various respects upon the German pattern. Speaking of the late meeting which was held in September at Gratz, the chief town of Styria, in one of the most beautiful valleys of the Austrian Alps, after noting that the number of those in attendance corresponds very nearly with the average number of attendants at the British Association, he adds that, although this may be a merely fortuitous resemblance, yet "both associations are convened for the same number of days; both hold the same number of general and sectional meetings; they resemble each other in the nature of the recreations offered to visitors—excursions, dinners, and concerts, to which, in Germany and Austria, are added balls and theatrical performances, while England has the private hospitality of its nobles and rich manufacturers and merchants to offer, which does not enter into the German programme, or certainly does not appear in it to the same extent. A festivity of a peculiar character, in addition to those named, was offered by the municipality of Gratz: an illumination by bonfires of the mountains surrounding the town, a sight of most impressive beauty."

The chief points of contrast in the proceedings of the two bodies are stated to be that, "generally speaking, there are no evening meetings in Germany, and, the festivals being of a public nature (not depending upon private hospitality), the connection between the visitors is greater than it is at the British meetings. The peculiarity of the German meetings is the absence of a president; two *chargés d'affaires* being nominated to conduct the business of the Association—one a natural philosopher and the other a physician. The sections nominate new presidents for each of their daily meetings. A consequence of this arrangement is a certain want of formality. No retrospective introductions (presidential addresses) are offered at the opening of the sectional meetings, no criticisms of the work of fellow-workers by more or less competent critics, no sweeping remarks on the state of science in general. In two respects the British Association has an indisputable advantage over the German meetings. Those splendidly illustrated evening lectures addressed to the general public, which form one of the attractions of the meetings in the United Kingdom, are not offered in Germany. Again, the funds of the German Association are small; they are spent for the purposes of each meeting, and no money can be given in grants for scientific purposes, as is done in Great Britain. On the other hand, the German Association offers the advantage of a speedy publication of its transactions. Instead of publishing an annual volume long after the close of the meetings, the German Association offers a daily paper, giving the proceedings in a more or less condensed form, according to the notes given by members to the general or sectional secretaries. Generally, some supplementary numbers are issued completing the report within one month after the conclusion of the meeting."

The German scientists are furthermore contrasted with those of England by their more pronounced repudiation

of utilitarian aims. English science has flourished under the stimulus of a pressure from the practical arts which has powerfully influenced the direction of investigation; the problems being given by art are accepted by science for solution. The eminence of England in commerce, navigation, manufactures, and locomotion, has impressed itself upon English science, which, while recognizing its true work to be the increase of original knowledge and new discoveries, will yet not lose sight of the great practical results to be attained through such discoveries. German science, on the other hand, still influenced by the spirit of its barren philosophies, vehemently protests against this alliance with the practical and the useful. It is never done denouncing the sordid, bread-and-butter philosophy of the English. In exemplification of this feeling, a passage is given from an address of Lieutenant Weyprecht on arctic explorations, in which he says: "Originally it was the wish for material gain in the shape of fur and fish-oil that prompted arctic exploration. Later on, this cause was replaced by the ambition of geographical discoveries, such as are easily understood by the general public. The running after this sort of fame gradually assumed such proportions that arctic exploration became a sort of international steeple-chase toward the north-pole, a system opposed to true scientific discoveries. Topographical geography must be subordinated, in arctic regions, to physical geography. Geographical discovery derives its value only from scientific discoveries connected with it. The exploration of the great and unknown latitudes near the poles of our globe must be continued without regard to the expenditure of money and of life which it demands. But its ulterior aim must be higher than the mere sketching, and christening in different languages, of islands, bays, and promontories buried in ice, and the mere reaching of higher latitudes than those reached by our predecessors. One reason of the indifferent results of previous expeditions is, that they have been unconnected with each other. The progress of meteorology consists in comparison, and every success it has obtained, such as the laws of storms, the theory of winds, etc., is the result of simultaneous observations. The aim of future arctic explorers must be to make simultaneous observations, extending over the period of a whole year, with identical instruments and according to identical rules. In the first place, they will have to consider natural philosophy and meteorology, botany, zoölogy, and geology, and only in the second place the discovery of geographical details. I do not intend in what I said to depreciate the merits of my arctic predecessors, whose sacrifices few can appreciate better than I do. In giving utterance for the first time to these opinions, which I have taken time in forming, I complain against myself, and I condemn the greater part of the results of my own arduous labors."

Germany is again contrasted with England in the completeness with which science is separated from religion, a result we should hardly have expected among a people so prone to philosophical speculation. Their scientists pursue their investigations with but very small regard to the bearings they may have upon theological beliefs. The writer whom we have quoted gives an illustration of this in a lecture delivered at the Gratz meeting by Prof. Benedict on the history of crime with regard to ethnology and anthropology. "He touched upon delicate ground, asserting that every action is based less on liberty than on compulsion; that our acts are governed by natural laws, and not by theological opinions; and that punishment may act as a corrective of perverted human nature, but is chiefly the outflow of the desire of society to avenge wrongs inflicted upon it. The best prevention of crime depends upon the in-

crease of our knowledge of those circumstances that necessarily engender it. In England a speech like this would, no doubt, have raised a storm of theological indignation. In Germany the clergy is distinguished by its absence from scientific meetings. The separation of natural science and orthodoxy is complete, and no opposition was therefore offered to these remarks."

The tendency of English science to occupy itself more or less with religious questions has several causes. In the first place, there is a large and cultivated clerical class whose professional duties are nominal, and who devote themselves earnestly to scientific studies. These mingle in the scientific societies and associations, and bring with them the bias of theological doctrine. Much money has, moreover, been expended in England, in the way of prizes, to be given to writers for making scientific books, for the advancement of theological views; and, as shown by the Bridgewater treatises, some of the most eminent and influential scientific men have sanctioned this practice, which has been much imitated by others of inferior ability. Such a course could hardly fail to arouse reaction and stimulate controversy. But, besides these causes, a cause still more efficient has been in operation there, in the rise of a school of psychology, that has brought old and fundamental theological doctrines and dogmas into the arena of scientific scrutiny, so that scientific men, in the performance of their duty as investigators, find themselves brought into collision with the "defenders of the faith."

But, while English science is much complicated with theology, it is but very little affected by politics. On the other hand, the political perturbations of German thought are deeply felt in its scientific assemblages. While English science is laboring to free itself from undue theological influence, German science is struggling for freedom of thought from undue political influences. This was the burden of the opening addresses of the September meeting. The Association was formed upward of half a century ago, and the writer in *Nature* says that politics entered into the intentions of its founder —the celebrated Oken, Professor of Zoölogy at Jena—as well as of many of its original members. "When German unity was nothing but a treasonable aim of persecuted patriots, every meeting of Germans from different states served to spread and to give fresh vigor to this aim, and was in itself a protest against the division into small states of the common country, and against persecutions such as Oken himself has had to suffer. Ay, and even now, when the old wishes have been fulfilled, and no division separates government and nation, remains of the old political undercurrent can still be traced in some of these meetings."

The interest of German men of science in political subjects is, therefore, an incident of the disturbed condition of the people, rather than any tendency to the purely scientific study of political and social problems.

We have a great amount of declamation on the dignity of mind, but we shall have a rational appreciation of that dignity just in proportion as we understand the laws of mind: what we need, therefore, is a broader and clearer apprehension of mental science. The attention of students of this subject is called to the weighty and suggestive article which opens the present number of The Monthly, on "The Comparative Psychology of Man." It treats of a phase of the subject of great moment, but hitherto only slightly regarded. It will be evident to all readers that the view taken by the writer is one that must be permanently recognized in future if mental phenomena are to be interpreted on strict scientific principles. But the article, moreover, remarkably

exemplifies the close interdependence of the higher and more complex sciences. Those who have been slow to comprehend the alleged important bearing that psychology has upon sociology will see that the two subjects are so inextricably involved—the mental organism and the social organism having been developed together by intimate interaction—that neither can be elucidated in a really scientific way without working out its relations to the other. The article affords an excellent illustration of the fruitfulness of investigation from the genetic point of view.

LITERARY NOTICES.

CURRENCY AND BANKING. By BONAMY PRICE, Professor of Political Economy in the University of Oxford. Pp. 176. Price, $1.50. D. Appleton & Co.

THE author of this book is not a stranger to the American people. He made a tour of the country a year or two since, and was called upon at various points to express his views on currency and finance, which he did with a bluntness and pungency that made a deep impression upon his hearers, and upon all who read his well-reported addresses. It was felt by many that his views were sound and important, and that it would be an advantage to the country if he would give us a season of lecturing upon the subject. But, as he could not remain, he agreed to do the next best thing, which was, to prepare a little volume, to be published in this country, giving a condensed exposition of his views. This volume is now issued and will be widely read, as well for its vivid and racy controversialism as for its sound and instructive teachings upon the topics discussed. Besides the Appendix, it is divided into three parts: first, "Metallic Currency;" second, "Paper Currency;" and third, "What is a Bank?" Prof. Price insists that there is really very little mystery about this subject that is generally regarded as so mysterious; while he admits that there is more error and absurdity and stupid nonsense put forth regarding it than upon almost any other subject of current speculation. A main cause of this, he states to be, the credulous confidence with which the public listens to the outgivings of men whose authority comes not from any intelligent or scientific understanding of the subject, but from the circumstance that they deal in money and have a great deal of it, and much to do with it. But practical familiarity with business operations, he maintains, is very far from conferring insight into the philosophy of such operations. A blockhead may make money, and make a parade of all the technical terms of finance, but know no more of the principles of the subject than the veriest beggar who hardly sees a dollar from one year's end to another. Yet the public pricks up its long ears to listen to the oracular twaddle of brokers, bankers, merchants, and treasury officials, who only confuse and confound the subject with their discordant utterances. Such books as those of Price and Jevons will do much to clear away the fog that has gathered around monetary questions in this country, and they should be widely circulated and carefully read, especially by young men who would prepare themselves to take a useful part in public affairs.

ELEMENTS OF METEOROLOGY. PART II., METEOROLOGICAL CYCLES. By JOHN H. TICE. St. Louis, 1875. Pp. 208. Price, $2.50.

WE have in Mr. Tice's book another wild and fruitless attempt to explain all phenomena by electricity. As, in former times, unexplained phenomena were ascribed to magic or supernatural power, so in modern days the unscientific look to electricity as the efficient cause of all physical mysteries. The author of this book admits no force but electricity. Mechanics is a nightmare, centrifugal force is electric repulsion, the perturbing force of a planet is only electric attraction, and all the phenomena of our atmosphere arise from electrical causes.

The volume before us is Part II., and from the preface we learn that Part I. has never been published; we are, however, not left in doubt as to its contents. We are told on the first page that in Part I. we can learn "all about the nature and constitution of rain and snow storms; all about cold and hot, wet and dry, seasons; and all about winds, gales, tornadoes, and hurricanes." If Mr. Tice has done half of what he claims, he has done enough to secure immortal fame. Nevertheless, after an ex-

amination of Part II., we are seized with a violent longing to be spared from Part I. The special function of Part II. is to establish meteorological cycles and to promulgate the theory of planetary equinoxes, on the strength of which Mr. Tice has made predictions which have gained for him considerable attention. It is unfortunate, however, for his reputation that he ever ventured into print; for no one can give his book the most cursory examination without detecting its unsoundness. Lack of space forbids more than a brief outline of Mr. Tice's theory. To point out all his errors in mathematics, physics, and astronomy, his false assumptions and logical fallacies, would require several pages.

All phenomena are periodic. "The regular recurrence of *identical* physical phenomena is an admitted fact." Were the cycle known, we could tell just when the phenomena of the past would be repeated. Mr. Tice considers the discovery of a meteorological cycle "the most *clamant desideratum* of the age." The discovery (?) of the Great Cycle was Mr. Tice's first step in the science of meteorology. It is exactly 11.86 years. He claims that this is established by the periodic phenomena of sun-spots, magnetic storms, cyclones, earthquakes, auroras, etc., but fails to give us the process of reduction. This period is identical with Jupiter's year, and the inference is that Jupiter is the cause of the cycle, which henceforth is called the Jovial Cycle. The idea of associating Jupiter with the eleven-year periods is not new, but we supposed it had been abandoned.

Mr. Tice's next stage is to prove that the phenomena of sun-spots, cyclones, etc., reach their maxima when Jupiter is at his equinoxes, and, of course, once every 5.93 years. This proof Mr. Tice gives in full with immense satisfaction, quite unconscious of its having not even a presumption in its favor. Finding nothing in his astronomy of Jupiter's equinoxes, he *assumed* that his solstitial points coincided with his points of greatest and least distance from the sun (aphelion and perihelion), as is the case, approximately, with the earth. The same groundless and false assumption is afterward made for the other planets, and such reasoning Mr. Tice calls "deduction from general principles" and "telluric analogy." Again, at its equinoxes the earth is at its greatest distance north and south of the plane of the sun's equator: Mr. Tice infers that the same is true of all other planets.

Mr. Tice calculates the equinoxes of the planets from their aphelia and perihelia, and accounts for the disturbing force of a planetary equinox on the supposition that the planet at its equinox is at its greatest distance from the solar equator, and hence exposed to only one pole of the sun. Thus, when the earth is at its vernal equinox, the north pole of the sun is invisible, and we are exposed to the full influence of its south magnetic pole. Terrific energy is then interchanged, disturbing both the atmosphere of the earth and that of the sun. The disturbances in the latter are communicated to the other members of the solar system. Similar results are produced at the autumnal equinox by the sun's north magnetic pole. When at their equinoxes the other planets undergo a like experience, and indirectly, through the sun, we share in the resultant electrical excitement. Such is the theory, and on such foundations does it rest. Historical records and the reports of the weather bureaus furnish endless confirmations, for every storm finds an equinox to bear the responsibility. In order to include all actual phenomena, the duration of an equinoctial period is put at one-fourth the planet's year, so that each planet spends half its time in creating disturbances throughout the solar system.

Not the least curious feature of the book is the adoption, into the family of planets, of the mythical Vulcan, supposed to have been discovered in 1859, and for a time believed to be a real planet, lying very near the sun. As nothing has been seen of it for the last dozen years, this looks very much like another assumption, of which, indeed, there appears to be no lack throughout the book.

PROCEEDINGS OF THE SEVENTH ANNUAL SESSION OF THE AMERICAN PHILOLOGICAL ASSOCIATION, held at Newport, R. I., July, 1875. Hartford, 1875.

THE meeting of the American Philological Association, of which this pamphlet is a record, was held at Newport, R. I., from July 13th to July 15th of this year. It

was opened by an eloquent and suggestive address from the President, Dr. I. Hammond Trumbull, who reminded the Association of the urgent need of attentive study of the structure of the languages of our American Indians, a need all the more urgent as they have no written language, and as year by year they are passing away. The vexed question as to a change in the present mode of spelling in English was also considered, and Dr. Trumbull avers that, while scholars agree on the question of the *desirability* of such a change, the main difficulty in the way of reform is the want of agreement among them as to the best way of effecting it. He says, "The objection that reform would obscure etymology is not urged by real etymologists;" and the testimony of Hadley and Max Müller is quoted, sustaining this position.

Again, the objection that words "when decently spelled would lose their 'historic interest' is equally unfounded. The modern orthography is superlatively unhistorical. . . . The only history it can be trusted to teach begins with the publication of Johnson's Dictionary." The important recommendation is made that a list of words be prepared, "exhibiting side by side the present and the reformed spelling," such that prominent scholars in England and America would recognize either form as allowable.

This subject was referred to a committee of five eminent philologists, who will report at the next annual meeting, and have liberty in the mean time to prepare such a list of words and cause them to be printed. This action assumes an additional interest from the fact that the State of Connecticut has already in contemplation such a change of spelling in its official reports and journals.

Important papers were read by Prof. Albert Harkness, Mr. A. C. Merriam, Prof. F. A. March, Prof. Franklin Carter, and others.

Many of these are, of course, of quite a special nature: among those of more general interest may be mentioned Prof. March's paper on "The Immaturity of Shakespeare as shown in Hamlet." In the report of Prof. March's paper in the "Proceedings," his analysis of the play, from this point of view, is brought into nine short propositions which are comprised within the limits of an octavo page. This brevity rather amusingly recalls Goethe's prolix analysis of the same play in "Wilhelm Meister;" it is by no means certain that Prof. March's summary will not help the puzzled reader of Hamlet quite as much as Goethe's chapters.

Another paper of interest was by Mr. C. M. O'Keefe, of Brooklyn, "On the Proper Names in the First Sentence of Cæsar's Commentaries."

ANNUAL REPORT OF THE SUPERVISING SURGEON OF THE MARINE HOSPITAL SERVICE OF THE UNITED STATES, FOR THE FISCAL YEAR 1874. By JOHN M. WOODWORTH, M. D. Washington, 1875. Pp. 256.

THIS report opens with a brief statement of what the Marine Hospital Service of the United States is; amount of collections and expenditures during the year; number of cases of disease and injury treated; and a comparison of the figures with those of previous years. Defects needing legislation; cost of the service to the government; port inspections and office dues; government hospitals; and preventive medicine in the service, are the subjects of succeeding sections. Then follow seventy pages of statistics classified under two heads: first, financial and economic; second, medical and surgical. Eleven papers under the following titles, and a copious index, occupy the last one hundred and fifty pages of the book: "The Hygiene of the Forecastle;" "American Commerce and the Service;" "Unseaworthy Sailors;" "Sailors and their Diseases in Chelsea Hospital;" "The Service on Cape Cod;" "The Freedman and the Service on the Ohio;" "Diseases of River Men, their Causes and Prevention;" "Preventable Diseases on the Great Lakes;" "Syphilis: the Scourge of the Sailor and the Public Health;" "Yellow Fever at Pensacola in 1874;" "The Yellow Fever Epidemic of 1873." These papers are by different authors, and will be found of interest by medical men.

THE MECHANIC'S FRIEND. By W. E. A. AXON. New York: Van Nostrand. Pp 339. Price, $1.50.

THE articles contained in this volume originally appeared in the *English Mechanic*, a practical magazine of sterling merit. The information may be relied on as trustworthy,

and the problems solved are precisely such as arise for solution every day in the workshop of the mechanic or the amateur handicraftsman. We cannot better indicate the character of the work than by naming a few of the heads under which the matter it contains is arranged. Thus we have the heading "Miscellaneous Tools, Instruments, and Processes," which includes hints on the microscope, hydraulic press, drills, screw-propeller, etc.; "Cements, Glues, Varnishes," "Solders," "Metals," "Steam-Engine," "Fire-arms," "Clock-work," "Glass," "House and Garden," "Drawing and Modeling," "Photography," "Musical Instruments," "Electricity and Telegraphing."

THE MECHANICAL ENGINEER: HIS PREPARATION AND HIS WORK. By R. H. THURSTON, C. E. Pp. 24. New York: Van Nostrand.

THIS is an address to a graduating class of the Stevens Institute of Technology, by the Professor of Mechanical Engineering. Prof. Thurston, in the first place, recalls to the minds of the young engineers the rare educational advantages they have enjoyed at the Institute: very full instruction in mathematics and physics; in modern languages; the English language and literature; principles of engineering, and the practice of the arts connected therewith. So far, the students have been working at the foundation; the superstructure they must build by their own efforts. The professor exhorts them to be wide-awake, observant, conscientious, true to their clients, progressive, radical in theory but conservative in practice, and diligent in study.

POLITICS AS A SCIENCE. By CHAS. REEMELIN. Cincinnati: R. Clarke & Co., Printers. Pp. 186.

IN this work the author well sustains the reputation he has long enjoyed of being a profound thinker. It contains the results of Mr. Reemelin's meditations during many years—meditations reduced to writing from time to time without any definite intention of publishing—upon the laws and phenomena of politics. As reading corrected his views, these detached meditations were amended, and gradually the purpose ripened to gather them together and put them in permanent form.

MELANOSIDERITE: A New Mineral Species from Mineral Hill, Delaware County, Pennsylvania; and on Two New Varieties of Vermiculites, with a Revision of other Members of this Group. By JOSIAH P. COOKE, Jr. From "Proceedings of the American Academy of Sciences." Pp. 12.

THE first of these papers is a brief description of the physical and chemical characters of a new mineral which, according to the author, is closely related to the sesquihydrates of iron. It contains about seventy-five per cent. of sesquioxide of iron, seven per cent. of silica, and thirteen per cent. of water, the remainder being alumina.

The second paper is a full account of the physical properties and chemical constitution of two new varieties of vermiculite, a mineral having a granular, scaly structure, and composed mainly of silica, alumina, magnesia, iron, and water. Its name is derived from the circumstance that, when heated, its scales open out into worm-like threads.

ON A FŒTAL MANATEE AND CETACEAN, with Remarks upon the Affinities and Ancestry of the Sirenia. By Prof. BURT G. WILDER. Reprinted from the *American Journal of Science and Arts*. Pp. 10. Illustrated.

THIS is a preliminary paper describing, with measurements, the external parts of a fœtal manatee, a little less than three inches long; and a fœtal cetacean but a trifle longer, and supposed to be the embryo of a porpoise or dolphin. Then follow some remarks on the affinities of the sirenia, in which the author, after referring to the present state of opinion on the subject, gives reasons for viewing them as near relations of the ungulates.

EXAMINATION OF GASES FROM THE METEORITE OF FEBRUARY 12, 1875. By A. W. WRIGHT. Pp. 6.

PROF. WRIGHT analyzed some fragments of the great Iowa meteorite of 1875, and the results of his investigation are given in the pamphlet before us. He finds the spectrum of the gases contained in the meteorite to closely resemble that of several of the comets. Other facts are cited to show that a comet is simply a meteorite of considerable magnitude, or a swarm of many of lesser size.

A REPORT ON TRICHINOSIS, as observed in Dearborn County, Indiana, in 1874. By GEORGE SUTTON, M. D. Aurora, Indiana. Pp. 23.

THIS is a remarkably clear and interesting history of an outbreak of trichina disease that was clearly traced to the eating of smoked but uncooked sausage. The disease was fatal in several cases, but the larger proportion of those attacked recovered. The author describes the symptoms of the disease, and the several modes of treatment that were adopted. The occurrence led to an extended examination of the pork produced in several counties in Southern Indiana, when it was found that from three to sixteen per cent. of the hogs that came under observation contained trichinæ. Though full of important information for the doctors and the public, this paper is, for pork-eaters, any thing but pleasant reading.

PREVENTIVE MEDICINE. By C. C. F. GAY, M. D. Pp. 12.

THE author of this address defends the paradox that disease is the *normal* condition, while health is the *abnormal* condition of our race. If this is the case, then prophylaxy and sanitation must be up-hill work indeed. Still to this work Dr. Gay does not hesitate to address himself, and his pamphlet contains many timely observations on various insanitary conditions of modern life.

HEALTH FRAGMENTS; OR, STEPS TOWARD A TRUE LIFE. By GEORGE H. EVERETT, M. D., and SUSAN EVERETT, M. D. New York: Charles P. Somerby. Pp. 306. Illustrated. Price, $2.

THIS book contains a few good things, that have been said a hundred times before, and that are here scattered through a large amount of nonsense which might better have been left unsaid.

MINERAL DEPOSITS IN ESSEX COUNTY, MASSACHUSETTS, especially in Newbury and Newburyport; with Map. By CHAS. J. BROCKWAY. Newburyport, 1875. Price, 50 cents.

THIS is a pamphlet of sixty pages, containing a popular account of the discovery, opening, and mode of working, of the new silver and lead mines in the locality named.

AËRIAL LOCOMOTION; PETTIGREW *vs.* MAREY. By Prof. COUGHTRIE. London, 1875. Pp. 20.

ON the first page of this pamphlet the author says his object is to show that, notwithstanding certain apparent differences, Pettigrew and Marey essentially agree in their views on the subject of flight. But the real object, as it appears from the remaining pages, is to prove by citations from both authors that Pettigrew anticipated Marey in most of his results, the latter, indeed, having claimed as original a great deal for which he was clearly indebted to Dr. Pettigrew. It is the old fight over again concerning priority of discovery, and in this case, according to our present lights, Pettigrew appears to have the best of the battle.

HALF-HOUR RECREATIONS IN POPULAR SCIENCE. Boston: Estes & Lauriat. Price per number, 25 cents.

NUMBER 13 of this series contains Tyndall's paper on "The Transmission of Sound by the Atmosphere," and an account of "Gigantic Cuttle-Fishes," by W. Saville Kent. In this paper the author recites the records of early observations of these monsters, the stories about which were considered doubtful until the recent discoveries off the coast of Newfoundland. The bulk of the article is a history of these later discoveries.

Number 14 is on "The Glacial Epoch of our Globe," by Alexander Brown. This is an interesting popular statement of how the theory of a glacial epoch arose, and of the investigations and theories relating to the constitution and movements of glaciers of celebrated observers. The number is illustrated.

Number 15 gives Balfour Stewart's address on "The Sun and the Earth;" a paper on "Force electrically exhibited," by J. W. Phelps; and two short articles entitled respectively "Weighing the Earth in a Coal-Pit," and The "Influence of Violet Light on the Growth of Animals and Plants."

PSEUDOMORPHS OF CHLORITE, AFTER GARNET. By R. PUMPELLY. Pp. 4.

OF interest to mineralogists exclusively. The paper is republished from the *American Journal of Science*. It is accompanied with two colored lithographs.

CAUSES OF IRREGULARITIES IN THE DEVELOPMENT OF THE TEETH. By N. W. KINGSLEY, D. D. S. Pp. 42.

THIS pamphlet contains a paper on the above subject, read before the Odontological Society of New York. Irregularity of teeth is shown to arise from three causes: 1. During the life of the individual, from cerebral disturbance while the teeth were forming; 2. Or before the individual life commenced, from like causes transmitted; or, 3. From mixing inharmonious types, large teeth with small jaws.

ON THE COTTON-WORM OF THE SOUTHERN STATES. By AUG. R. GROTE. Pp. 6.

IN this paper, reprinted from the proceedings of the Hartford meeting of the American Association for the Advancement of Science, Prof. Grote summarizes the results of five seasons' observation of the cotton-worm in the States of Georgia and Alabama. Where the moth first came from, its powers of flight, breeding habits, and the measures to be taken against its ravages, are among the interesting questions discussed.

THE *American Engineer*, published monthly at Baltimore, begins its third volume in enlarged form. Though primarily this journal addresses inventors and mechanics, it will be perused with interest by the general reader, who will find in its pages much useful scientific and industrial information. $1.00 per annum.

PUBLICATIONS RECEIVED

Condition of Affairs in Alaska. By H. W. Elliott. Washington: Government Printing-Office. Pp. 277.

Our Wasted Resources. By W. Hargreaves, M. D. New York: National Temperance Society. Pp. 201. Price, $1.25.

Dissertations and Discussions. Vol. V. By J. Stuart Mill. New York: Holt & Co. Pp. 294. Price, $2.50.

Soluble Glass. By Dr. L. Feuchtwanger. Pp. 168.

Report of the Commissioners of Education, 1874. Pp. 936.

Graphical Statics. By A. J. Du Bois, C. E. New York: Van Nostrand. Pp. 79.

Camp-Life in Florida. By Charles Hallock. New York: Forest and Stream Co Pp. 348.

Travel in Southwestern Africa. By C. J. Anderson. New York: Putnams. Pp. 329. Price, $2.00.

Strength of Beams. By W. Allan. New York: Van Nostrand. Pp. 114. Price, 50 cents.

Report of Prison Association of New York. 1874. Pp. 192.

State Medicine and Insanity. By Dr. N. Allen. Pp. 31.

Sewerage. By W. H. Corfield. New York: Van Nostrand. Pp. 128. Price, 50 cents.

Manufacture of Pottery among Savages. By C. F. Hartt. Rio de Janeiro: *South American Mail* print. Pp. 70.

Prospecter's Manual. By W. J. Schofield. Boston: Schofield & Co. Pp. 96. Price, 50 cents.

American Journal of Microscopy. New York: Handicraft Publishing Company. Pp. 12. Price, 50 cents per annum.

Check-list of Noctuidæ. By A. R. Grote. Buffalo: Reinecke & Zesch, printers. Pp. 28.

Difference of Thermal Energy transmitted from Different Parts of Solar Surface. By J. Ericsson. Pp. 10.

Report of Directors of the New York Meteorological Observatory, 1873. Pp. 34.

Currency. By G. B. Satterlee. Pp. 17.

Report of Directors of the California Institution for Deaf and Dumb and the Blind. Pp. 55.

Prohibition does prohibit. By J. N. Stearns. Pp. 48.

Odontornithes. By O. C. Marsh. Pp. 7.

Anæsthetics in Labor. By S. S. Todd, M. D. Pp. 25.

The Great Salvation. By J. W. Chadwick. Pp. 23.

MISCELLANY.

The Frailty of Modern Art.—The old masters made their own colors. The material which entered into their pigments came to them unadulterated, and the excellence of the paint depended on the brain mixed in it. Hence, their paintings to-day, though lacking somewhat freshness of color, have a mellowness which age can only give to pigments of the highest excellence. Modern pictures will not ripen, their colors fade, and the mellowness of the old masters is unattainable. Holman Hunt, of England, has called the attention of lovers of the fine arts to this deplorable fact. And the reasons are given. The artist's colors are no longer made by himself. Their manufacture is a business from whose secrets he is shut out. Artist's colors are subject to fearful adulteration. Even the oils cannot be genuine, as things go. The materials of which they are made go to the maker in a sophisticated state. Linseed and poppy-seed are adulterated before they reach the oil-maker's hands. So too, is it generally with the crude material for the pigments. A high-priced vermilion from an eminent dealer, upon analysis, yielded twelve per cent. of red lead. So the artist, who puts his whole life and soul into a painting that should be "a joy forever," has this immortality of art quenched by the use of dishonest paint.

Oscillations of Lakes.—The "seiches" of the lake of Geneva have for several years, as we learn from *Nature*, been under investigation by Forel, of Lausanne. The term "seiche" is applied locally to certain oscillatory movements occasionally seen on the surface of the lake. The phenomenon had been investigated by previous observers, among them Saussure and Vaucher, who attributed it to variations in atmospheric pressure; in this, Forel agrees with them. The same phenomenon occurs in other Swiss lakes, and Forel believes it will be found in all large bodies of water. He recognizes in the "seiche" probably the most considerable and the grandest oscillatory movement which can be studied on the surface of the globe. His investigations have led him to the conclusion that the "seiche" on the Swiss lakes is an oscillatory undulation, having a true rhythm, and that the phenomenon is not occasional, but constant, though varying in degree. The duration of a "seiche" is a function of the length and depth of the section of the lake, along which it oscillates; this duration increases directly with the length, and inversely with the depth of the lake. The instrument he has devised for the investigation of the phenomenon he calls a plémyramètre ("tide-measurer").

Contents of a Kitchen-Midden.—Prof. Cope lately exhibited to the Academy of Natural Sciences of Philadelphia a collection of animal remains, fragments of pottery, flint arrow-heads, etc., taken from an Indian kitchen-midden in Charles County, Md. The animal remains included the bones of seventeen species of vertebrata and two of shells. Of the vertebrates four were mammals, two birds, four reptiles, and seven fishes. The mammals were the Virginia deer, raccoon, gray squirrel, and opossum. Most of the deer-bones had been split into pieces lengthwise for the purpose of extracting the marrow. The birds were represented by a number of parts of the turkey, and the tarsometa-tarsus of some natatorial bird of the size of a widgeon. The reptiles were all turtles, and included the snapper, the box-tortoise, and two emydes. The fishes represented were the sturgeon and the gar, there were also numerous bones of Siluroid fishes of at least two species. The mollusks were *Unio purpureus* and *Mesodon albolabris*.

Habits of Blind Crawfish from Mammoth Cave.—In November, 1874, Prof. F. W. Putnam collected a number of blind crawfish (*Cambarus pellucidus*) in the Mammoth Cave, which he kept alive for several months afterward in Massachusetts. The habits of these animals and the reproduction in them of lost parts are the subject of a communication by Prof. Putnam, published in the "Proceedings of the Boston Society of Natural History." The animals eat but very little in captivity. When food is dropped into the jar in which they are kept, they dart backward, then extend the antennæ, and stand as if on the alert. The animal continues in this attitude for several min-

utes, and then cautiously crawls about the jar with antennæ extended. On approaching the piece of meat, and before touching it, the animal gives a powerful backward jump and remains quiet for a while. It often repeats this three or four times before touching the food, and when it does touch it the result is another backward jump. When it has become satisfied that there is no danger, it takes the morsel in its claws and conveys it to its mouth. "I have twice," says the author, "seen the meat dropped as it was passed along the base of the antennæ, as if the sense of smell, or more delicate organs of touch seated at that point, were again the cause of alarming the animal. When the jaws once begin to work, the piece of meat, or bread, if very small, is devoured, but if too large, only a few bites are taken, and the food is dropped and not touched again."

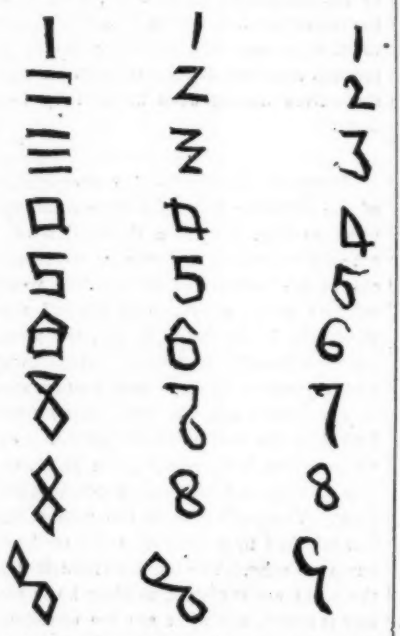
A detailed account is given of one of the specimens, in order to show the mode of reproduction of lost members. This specimen, a female, was captured November 13th, being then perfect in all respects, except the right, large claw, which was as yet rudimentary. Total length of the animal from tip of large claw to end of tail, not quite two and a half inches. From November 14th to 24th, the crawfish lost in battle most of her antennæ, the third, fourth, and fifth legs from the left side, the fifth from the right side, and the two end-joints of the third leg on the right side; January 28th or 29th she cast her shell and came forth with a soft white covering, which was nearly two weeks in hardening. All the legs which were perfect before were now of the same size, but in addition the great claw of the right side was developed to about one-half or two-thirds the size of its fellow, and was apparently of as much use. The two missing joints of the third leg on the right side were also developed, though not quite to their full proportions. The fifth leg on the right side, and the third, fourth, and fifth of the left side, were reproduced, but in a very small and rudimentary manner. The antennæ were about two-thirds their full size. On April 20th the shell was again cast; the crawfish had now all the legs and claws nearly perfect. The great claw of the right side was very nearly as large as that of the left. The tip of the third leg of the same side was perfect, and all the legs that before were rudimentary were now developed apparently to their full proportionate size, with the exception of the last on the right side. Antennæ about full length.

From these observations, it will be seen that the parts are not reproduced in perfection on one shedding of the shell, but that each time the shell is cast they are more nearly perfect than before.

Sound and Fog Signals.—Among the papers read at the Philadelphia meeting of the American Academy of Sciences, was one by Prof. Henry on "Sound and Fog Signals," of which we present an abstract. The author stated the results of experiments made last summer, under the direction of the Lighthouse Board, at Block Island, and at Little Jail Island, at the east end of Long Island Sound. One set of experiments was made to investigate the cause of an echo apparently heard from the ocean: the results were not such as to solve the problem, though they favored the hypothesis that the echo was due rather to a reflection from the waves than from the air. Another set of experiments was directed to investigating the effect of elevation on the hearing of sound; the result was to show that a sound traveling against the wind is heard farther away on an elevation than at the sea-level. In five cases, sound was heard five times farther with the wind than against it, the wind's velocity being about five miles per hour. The effects of sound traveling with the wind, against it, at right angles to it, etc., were shown in diagrams representing *curves of audition*. In still air these curves are nearly circular; with wind uniform in velocity throughout the whole space the curves are approximately elliptical. The curves differed according to the different conditions. It appeared to be demonstrated that sound is heard farthest with a moderate wind, and that with a strong wind it is heard a less distance in every direction than in still air, and perhaps to a less distance than with a wind of moderate velocity. These experiments will be resumed next summer.

Origin of the Numerals.—Having never met with any explanation of the origin of

the numerals, or rather of the figures symbolizing them, perhaps I am right in supposing that nothing satisfactory is known of it. In that case the following may be interesting to your readers: The first column contains the original figures, each containing as many lines as the number which it is intended to represent. The other columns show the transitions likely to result from quick writing.—W. DONISTHORPE in *Nature*.



Location of Sensory Centres in the Brain.—At the recent meeting of the British Medical Association, Dr. Brunton read a paper communicated by Dr. Ferrier, entitled "Abstract of Experiments on the Brains of Monkeys, with special reference to the Localization of Sensory Centres in the Convolutions." The experiments, which were conducted by trephining and the destruction of the sensory centres by means of a red-hot wire, led to the following results, as stated by the *Lancet:* These centres are bilateral, so that when, for instance, one of the centres of touch was destroyed, there was loss of tactile sensibility in the corresponding half of the body. Stimulation of the centre of hearing caused the animal to prick up its ears as if it heard something, while destruction of the whole of this centre rendered the creature totally deaf. Destruction of the centre of vision corresponding to one eye only, rendered the animal temporarily blind in that eye, the function, after twenty-four hours, being carried on by the opposite centre. In the discussion which followed, Dr. Nairne pointed out that other observers had arrived at conclusions different from those of Ferrier, and that the brain of a monkey could not be taken as exactly similar to that of a man; but Dr. Brunton thought the mistake made by German and other investigators who differed from Ferrier was, that they took the brains of animals lower even than the monkey to correspond with that of man. Dr. Dupuy said that he had found, when the centres of motion on one side of the brain were removed, that paralysis followed for a short time throughout the corresponding part of the body, but that, when the centres were removed from both sides of the brain, there was no paralysis at all.

Health of Children in Utah.—In a report made by Surgeon E. P. Vollum to the Surgeon-General on "Some Diseases of Utah," it is stated that the adult population of that Territory is as robust as any within the limits of the United States. The children furnish two-thirds of all the deaths, most of which occur under five years of age. In Salt Lake City, as appears from the register kept by the undertakers, the male deaths exceed the female in number about 50 per cent., but Surgeon Vollum could not get the relative proportion. The polygamous children are as healthy as the monogamous, and the proportion of deaths about the same, the difference being rather in favor of the former, who are generally, in the city especially, situated more comfortably as to residence, food, air, and clothing, their parents being in easier circumstances than those in monogamy. It is perhaps still too early to form an opinion as to the influence of polygamy on the health, or constitutional or mental character of the Anglo-Saxon race in Utah; but Surgeon Vollum has been unable to detect any difference in favor either of monogamy or polygamy. So far as he can learn, polygamy in Utah furnishes no idiocy,

insanity, rickets, tubercles, struma, or debasing constitutional condition of any kind.

Vehicles of Infection.—A number of cases of the transmission of contagious diseases by means of clothing, articles of furniture, and other objects that had been in contact with persons stricken by such diseases, are brought together by a writer in *Chambers's Journal*, in order to show the great importance of thoroughly disinfecting such vehicles of infection, before making use of them again. The author, Mr. William Chambers, in the first place quotes Sir James Simpson's remedy for hospital-infection, namely, building such establishments of cast-iron, and casting them anew when contaminated. A servant-girl in Morayshire died of scarlet fever. Her clothing was sent back to her parents, but *en route* the box lay over for a few days at a railway-station. On reaching its destination, the contents of the box were dispersed among friends and neighbors. The children of the station-master, who had played around the box, and every recipient of the infected clothing, were stricken with the fever. Again, the clothing of a soldier who had died of cholera was sent home to his friends. While the garments were "in the wash," a man was employed on the roof of the cottage, repairing the thatch. He inhaled the poisonous fumes of the washing, and died of cholera. Scarlet fever of a malignant type appeared in a family at Carlisle, and two of the children died. In this case, the carrier of the infection was a retriever-pup, which had been reared in a house where scarlatina was present. It is stated in a pamphlet by Dr. McCall Anderson, of Glasgow, that a peculiar disease was introduced into a family in that town under the following circumstances: Some mice, caught in a trap, were seen to have on the head and front legs crusts of a sombre yellow tint, of circular form, and more or less elevated above the level of the neighboring healthy parts. A depression was noticed in the centre of each crust, and the parts where these had fallen off were ulcerated, and the skin appeared to be destroyed throughout the whole thickness. These mice were given to a cat, which soon exhibited, above the eye, a crust similar to those on the mice. Later still, two young children of the family who played with the cat were successively affected with the same disease, yellow crusts making their appearance on several parts of the body, on the shoulder, face, and thigh. Other instances are cited by Dr. Anderson, where mice, affected in the same way, had transmitted the disease to the human subject, both indirectly through cats, and directly through the mice themselves having been handled by children.

Practical Education.—A correspondent of the *Moniteur Industriel Belge* communicates to that journal a description of a school of practical instruction, situated in one of the suburbs of Paris. The writer exhibits to us a system of education in which the future occupations of the pupils are kept steadily in view, and where every step of progress in study marks an advance in real knowledge. A few instances will best show the method of instruction. Suppose a lesson in botany is to be given, and that the special subject is some textile plant. The pupil sees, in the botanic garden attached to the school, a few stalks of hemp growing. The botanic characters of the plant are explained to him; he is told how it grows, and what are the conditions favorable to its growth; then he is shown how it is treated in order to obtain the fibre, how the latter is spun, woven, etc. In giving instruction on minerals, a like course is followed. For instance, the subject is iron-ore: various kinds of ore are exhibited; the processes are explained, by means of models and designs, of the reduction of iron and its manufacture. So in mechanics: models of machinery are shown and explained; better still, the pupil is taken to the workshops where he sees various kinds of machines in operation. His understanding of things is tested by questions, and by being required to draw the objects he has been looking at, and to explain their working. Topography and geography are taught in the same common-sense way, the pupil being led to map out an ever-widening area. He begins with the plan of the school, then gives its relative position in the commune, in the canton, in the arrondissement, and so on. The great

principle of instruction in this school is "to make knowledge concrete, practical."

Revivals and Religious Insanity.—In a paper by G. H. Savage, M.D., of the Bethlehem Hospital for the Insane, London, on "Religious Insanity and Religious Revivals," the lists of cases admitted to the hospital during the four months April to August, in the three years 1875, 1874, and 1873, are compared. The result does not show any increase of insanity traceable to the recent religious excitement in England. Indeed, the author sees no reason for regarding religious insanity as a peculiar, well-defined species of mental disease. According to him, it is simply an accident of education, temperament, or sex, whether certain subjective feelings develop themselves into a morbid religious idea, or into an illusion of being persecuted and annoyed by others. "Many persons," he adds, "verging on insanity—in fact, in the melancholy stage of the disease—seek religious consolation, and, notwithstanding this, go mad; they would probably have gone mad in any case, and the most that can be said against the service is that it precipitated the attack." But to return to the figures. In 1875, from April to August, there were admitted to Bethlehem 42 male patients, and of these 9 suffered from religious insanity. During the same time 55 women were admitted, of whom 8 had religious delusions. That was 21.4 per cent. of the men, and 14.5 per cent. of the women. During 1874, in the same period, 30 male admissions gave 6 religious cases, and 47 female cases gave 16—that is, 16.6 and 34 per cent. respectively. In 1873, 28 male admissions gave 4 religious cases, or 14.2 per cent.; 28 female admissions gave 8 religious cases, or 28.4 per cent.

NOTES.

We have received from Prof. W. S. Barnard the following correction of a statement in his article on "Opossums and their Young," published in the December MONTHLY: "In your December number I stated that the delivery of young opossums had never been witnessed. To the contrary see observations of Mr. J. G. Shute, in the 'Proceedings of the Essex Institute,' vol. iii., page 288, to which my attention has just been called. The female curves her body until the sexual orifice is opposite the pouch, which opens by muscular contraction to receive the young, without any assistance from the paws or lips."

The largest telescope ever yet attempted is now in course of construction in Dublin by Mr. Grubb. It is intended for the new Observatory of Vienna. The object-glass will have an aperture of over twenty-six inches, and the focal length is to be about thirty-two feet.

In the *American Journal of Science and Arts* for November Prof. Marsh has a short illustrated paper describing the remains of several fossil birds obtained from the Cretaceous of Kansas, and possessing teeth.

We learn from the *Scientific American* that the excavations at Hell-Gate were completed about the end of July. The work now in progress consists in the boring of holes for the charges of nitro-glycerine. This was to have been completed before the end of the year 1875, and then two or three months more would be occupied in inserting the charges.

A curious race of sheep, living on an island in Englishman's Bay, coast of Maine, are described in *Forest and Stream*. They are nearly as wild as deer. Their principal winter food is sea-weed, chiefly dulse; they also eat the branches of nearly all the trees which grow on the island.

In very early times the pine appears to have been the principal forest-tree of Denmark. At present the beech occupies this position, and the pine is no longer indigenous in the country. Next after the beech comes the birch, then the alder, the aspen, the hazel, etc. An examination of the vegetable *débris* of the bogs of Denmark shows that the pine was followed immediately by the sessile-fruited variety of the oak, and this in turn by the beech.

In illustration of the influence of nutrition on the habits of plants, Mr. Meehan, of Philadelphia, cites the case of two species of *Euphorbia*, which, though usually prostrate, he found assuming an erect growth when their nutrition was interfered with by a small fungoid parasite. A similar fact was observed in connection with the common purslane, one of the most prostrate of all procumbent plants, which, under similar conditions, also became erect.

Dr. Nicolas von Konkoly finds in the *train* of meteors the spectrum-lines of sodium, magnesium, carbon, strontium, and possibly lithium, while the nucleus invariably gives a continuous spectrum, in which the yellow, the green, or the red predominates, according to the color, blue being very rare, and violet never seen.

At the trial of the 81-ton gun, at Woolwich Arsenal, a 1,250-pound ball was fired with a charge of 170 pounds of powder. This shot penetrated 45 feet of sand, and the recoil of the gun was 23½ feet. A second shot was fired with a charge of 190 pounds. The penetration-distance was now over 50 feet, and the recoil 32 feet. It is intended gradually to increase the charge to 300 pounds.

A State Archæological Association has been formed in Ohio to promote investigation of the mounds and earthworks of the State, to collect facts, descriptions, relics, and other evidences of the prehistoric races, and to awaken an interest in the general subject of archæology. The library and cabinet of the Association will be established in the State-House, at Columbus, provided the State furnish suitable accommodations free of cost. The meetings will be held annually in the various cities of Ohio, and a yearly bulletin will be published. The first annual meeting will be held at Newark, Licking County, on Tuesday, September 5, 1876.

A quarter of a million of young salmon, according to a writer in *Forest and Stream*, have been placed in the Truckee River, which flows into Lake Tahoe, Nevada, and they are doing well.

A vein of nickel has been discovered in New Caledonia, extending across the entire island, from east to west. There are also in New Caledonia copper-mines of great richness. The gold-mines, of which much was expected a few years ago, have so far yielded insignificant results.

The death-rate of some English towns is very high. Thus, while the death-rate for England and Wales generally is 22.2 per 1,000, in Bristol it is 26.9, in Leeds, 28.7, in Manchester, 32.1, and in Liverpool, 35.9. Of children under five years of age, 39 per 1,000 die annually in country districts, while in towns the ratio is 103 per 1,000.

A commission has been appointed by the British Government, to investigate the subject of the spontaneous combustion of coal on shipboard. Persons having any facts on the subject of the spontaneous combustion of coal, under any circumstances, are requested to communicate the same to H. S. Poole, Charlottetown, Nova Scotia, Inspector of Mines.

Microscopic examination of the muscular tissue of a wild-boar lately shot in the forests of Saxony showed it to be full of trichinæ. This is the first case in which this parasite has been found in the wild-boar, it having been the general belief that only domesticated swine were affected.

By substituting atomized water or spray for steam in sulphuric-acid manufacture, Sprengel not only effects a saving of fuel, but also saves 6½ per cent. of pyrites and 15 per cent. of nitre.

An adequate punishment for those human brutes who vent their despicable passions in murderous assaults on women and children is suggested by the authors of "The Unseen Universe." "It is probable," they write, "that, before many years have passed, electricity will be called upon by an enlightened legislature to produce absolutely indescribable torture, thrilling through every fibre of such miscreants."

A process for brightening iron is described as follows in a German periodical: The articles to be brightened are, when taken from the forge, placed in dilute sulphuric acid (1 to 20), and then washed with water and dried with sawdust. They are then dipped for a second or so in nitrous acid, washed carefully, and rubbed clean. Iron thus treated acquires a bright surface, having a white glance.

They are trying to introduce humble-bees into New Zealand, for the purpose of aiding in the fertilization of the common clover. This office the common bee is unable to discharge, its proboscis being too short to reach down to the pollen of the flower.

A university, to be founded at Tomsk, Siberia, by the Russian Government, will at first consist of only two Faculties, law and medicine. Siberia at present is very ill supplied with doctors, there being only 55 for a population of 6,000,000, inhabiting a territory as large as all Europe.

Hofmann's process for preparing vanilla from the wood of the pine has been patented, and will be generally applied in paper-mills which use wood-pulp for the purposes of their manufacture.

It is stated in the *Lancet* that female medical missionaries are now laboring very successfully in various parts of India. The Maharajah of Vezianagram has engaged an American lady to open a dispensary for women at Benares, and Sir Salar Jung has done the same thing in Hyderabad.

Bath bricks are made from the deposits of the river Parrett, at Bridgewater, Somersetshire. Nowhere else is a similar deposit found, so that Bridgewater supplies the world. The annual import into the United States is about 240,000 bricks.

The State of Minnesota produced last year 28,000,000 bushels of wheat, 15,000,000 of oats, and 12,000,000 of Indian-corn.

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